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SWEET-CORN INBREDS and CROSSES

Released by the Illinois Station

By W. A. Huelsen

UNIVERSITY OF ILLINOIS
AGRICULTURAL EXPERIMENT STATION
Bulletin 466
Sweet-Corn Inbreds and Crosses
Released by the Illinois Station
By W. A. Huelsen, Chief in Olericulture

DEVELOPMENT OF INTEREST IN HYBRIDS

That yields of corn can be increased by crossing two continuously inbred lines has been known since East\(^5\) and Shull\(^4\) demonstrated the effect of hybrid vigor in 1907 and 1908. At that time, however, the methods used in inbreeding and crossing promised nothing of commercial value; selection seemed more promising, in view of the results obtained by Hopkins\(^7\) and L. H. Smith.\(^16\)

Consequently, for many years breeders continued to select rather than to inbreed. In 1918, however, following Jones\'s\(^10\) discussion of heterosis, interest in single and double crosses revived. Since then almost all corn breeders have depended entirely on inbreeding and crossing to obtain better strains of corn.

In spite of the slight attention paid to sweet-corn breeding as compared with field-corn breeding, the first large-scale commercial plantings of crosses were made with sweet corn. The circumstances which brought this about are an excellent illustration of how advances in one field of research (breeding) are dependent on those in another (engineering).

In the early days of canning, sweet corn was husked by hand and the kernels cut from the cobs with butcher knives. The canned product was known as “whole grain,” or “Maryland” style corn. The first cutting machine was introduced in 1882. This and subsequent machines cut the tops from the kernels and then scraped out the remaining kernel contents, giving a canned product known as “Maine” or “cream” style corn. The older whole-grain type, because of the higher cost of hand methods, practically disappeared from the market.

In 1929 a whole-grain cutter was introduced. This machine cut the kernels down to the cob irrespective of the shape and size of the ear. The cost of packing whole-grain style was thus reduced and packers turned their attention to this item. Further impetus was given to whole-grain corn by the perfecting of can-closing machines which sealed cans in a high vacuum. This invention permitted canning the so-called “dry pack” or “vacuum pack”—a product more nearly like fresh corn than any other. The effect of these inventions was revolu-

*These numbers refer to literature citations on page 355.
tionary; by 1937 about 30 percent of all the corn packed was whole-grain style.

Popular preference has turned since about 1930 in the direction of yellow varieties of sweet corn over the white types. In 1938 more than half the total pack of sweet corn and about 80 percent of the whole-grain pack was yellow. The numbers of cases of the different kinds of corn packed in 1936, 1937, and 1938 were as follows:

<table>
<thead>
<tr>
<th></th>
<th>1936</th>
<th>1937</th>
<th>1938</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total pack, all types</td>
<td>14,621,189</td>
<td>23,541,224</td>
<td>20,469,518</td>
</tr>
<tr>
<td>Cream style, white</td>
<td>5,635,960</td>
<td>9,701,301</td>
<td>7,345,957</td>
</tr>
<tr>
<td>Cream style, yellow</td>
<td>4,947,010</td>
<td>7,493,909</td>
<td>7,624,369</td>
</tr>
<tr>
<td>Whole-grain style, white</td>
<td>1,148,920</td>
<td>1,459,634</td>
<td>1,158,729</td>
</tr>
<tr>
<td>Whole-grain style, yellow</td>
<td>2,890,560</td>
<td>5,668,206</td>
<td>4,717,787</td>
</tr>
</tbody>
</table>

When this change in preference toward yellow sweet corn began to take place, ordinary Golden Bantam was the most suitable yellow variety available. Inasmuch as canners had previously been interested chiefly in the white types, breeders had paid very little attention to the yellow. Golden Bantam, however, being very susceptible to bacterial wilt, is suitable only for northern climates and is not particularly well adapted to Illinois.

In 1931 G. M. Smith\(^*\) introduced a yellow first-generation hybrid (Purdue 39 × 51) under the name of Golden Cross Bantam. Practically coinciding with the introduction of the whole-grain cutter and the vacuum-pack process, this cross met a very insistent demand. Used more or less wherever sweet corn is packed, it is now the most widely grown sweet-corn hybrid in use today. Demand for seed of this cross has compelled seedsmen to learn how to produce hybrids on a large scale. Golden Cross Bantam has also demonstrated that good hybrids are adapted over a surprisingly wide range of climate and soils.

Any remaining doubts which corn breeders may have had were dispelled by the severe drouths of 1934 and 1936, which demonstrated that crosses give the greatest comparative increases in yields over open-pollinated strains under the most severe conditions.

Despite numerous tests, however, and considerable commercial experience with hybrids, the full behavior of crosses under actual field conditions is still imperfectly understood. Very little is known regarding such questions as regional adaptability of crosses, the ultimate effect of inbreeding for many generations, and the merits of single crosses as compared with other types. Furthermore, little actual information is available regarding the means of successfully maintaining superior inbred lines.

\(^*\)Twenty-four No. 2 cans per case.
At the Illinois Agricultural Experiment Station breeding work with sweet corn was begun in 1922. At first the work was confined to Country Gentleman and Narrow Grain Evergreen varieties, but in 1930 yellow varieties were included. During the eighteen years of breeding work thru 1939, more than a thousand inbred selections were made and more than four thousand crosses were tested. From among all these, twelve inbred lines have been released to the seed trade, and the crosses of the earliest releases, made in 1935, have come into extensive use. It is the purpose of the present bulletin to describe the inbreds which have been released and their use in crosses, and to discuss in addition some of the problems of inbreeding and crossing upon which light has been thrown by the experimental breeding work and the commercial production of both the inbreds and the crosses.

**ADVANTAGES OF SINGLE CROSSES**

The true value of single crosses to the grower appeared during the severe drouths of 1934 and 1936, when it became apparent that a well-adapted cross had a smaller variation in annual yields than open-pollinated strains. In open-pollinated sweet corn the range in yields from season to season is from less than 1 to more than 4 tons of unhusked ears to the acre. The superiority of the crosses in this respect is shown by the six years' results of yield tests at the Illinois Station summarized in Table 1. The annual yield variation is indicated by the coefficient of variability, which for Cross $8 \times 6$ was consistently less than for the open-pollinated strains for all the yield components except cans per gross ton, in which component there was practically no difference.

Differences in yield of prime cut kernels (percentage basis) between the cross and the open-pollinated check in Table 1 were largest in the most adverse seasons (1931, 1933, 1934, and 1936) and least during the favorable seasons (1935 and 1937). Thus as an indication of the value of a cross, its performance in a favorable year is not as good a criterion as its performance in an adverse season.

Differences very similar to those in Table 1 also appear in tests of

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*Unstandardized genetic terms have caused much confusion. The terms "single cross," "first-generation hybrid," "cross" and even "hybrid" are used interchangeably by most writers. For a cross between two inbred lines, the term "single cross" is preferred, and is used here. The term "top cross" means a cross between an open-pollinated seed parent and an inbred line. "Hybrid" is used here as a general term to denote crosses of all kinds, collectively.
Table 1—Yields of the Well-Adapted Country Gentleman Single Cross 8 X 6 and of an Ear-Row-Selected Open-Pollinated Country Gentleman Strain of Sweet Corn at Urbana, 1931 to 1937

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of trials</th>
<th>Tons per acre</th>
<th>Open-pollinated Cross</th>
<th>Prime cut kernels per gross ton</th>
<th>Casea per acre</th>
<th>Standard error</th>
<th>Coefficient of variability (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931</td>
<td>9</td>
<td>2.521</td>
<td>1,082</td>
<td>2,902</td>
<td>0.023</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>1933</td>
<td>8</td>
<td>2.463</td>
<td>1,126</td>
<td>2,939</td>
<td>0.029</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>1934</td>
<td>5</td>
<td>2.492</td>
<td>1,124</td>
<td>2,941</td>
<td>0.027</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>1935</td>
<td>6</td>
<td>2.339</td>
<td>1,159</td>
<td>2,886</td>
<td>0.025</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>1936</td>
<td>5</td>
<td>2.349</td>
<td>1,159</td>
<td>2,886</td>
<td>0.025</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>1937</td>
<td>5</td>
<td>2.349</td>
<td>1,159</td>
<td>2,886</td>
<td>0.025</td>
<td>0.003</td>
<td>0.003</td>
</tr>
</tbody>
</table>

The open-pollinated strain was tested each year on the germplasm and only disease-free seed of high germination was planted, thus giving a bias to the test. Calculated on a test of basis, allowing 22 pounds cut kernels and 1 gallon milk per case, assuming no starch added.
field-corn hybrids. In the performance trials of Dungan et al. in northern Illinois in the drouth year 1934, four good hybrids averaged 20.2 bushels more sound corn per acre than the five best open-pollinated varieties, but in 1935, a more favorable year for growing corn, the four hybrids averaged only 10.9 bushels more per acre than the open-pollinated varieties. The four hybrids averaged 67.2 bushels per acre in 1934 and 87.8 bushels in 1935, and the open-pollinated varieties averaged 47.0 bushels in 1934 and 76.9 bushels in 1935.

Annual yield differences as variable as these have deceived corn breeders in the past and will most likely deceive corn growers in the future. Crosses should be considered as a form of crop insurance, producing in favorable years only slightly more than open-pollinated varieties, but holding up much better than the open-pollinated varieties when growing conditions are unfavorable.

**NATURE OF INCREASED YIELDS OF SWEET-CORN CROSSES**

In the yield performance of several thousand sweet-corn crosses over a period of twelve years, the single crosses and open-pollinated strains did not differ as much in yields of unhusked ears as in yields of cut corn. The yields of husked ears tended to be intermediate between the two. This relationship is obvious in the following data on yields of Cross $8 \times 6$ (six-year-averages, Table 1):

<table>
<thead>
<tr>
<th></th>
<th>Increase over open-pollinated checks</th>
<th>Percent increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unhusked ears, per acre</td>
<td>.488 ton</td>
<td>18.6</td>
</tr>
<tr>
<td>Husked ears, per acre</td>
<td>.538 ton</td>
<td>33.9</td>
</tr>
<tr>
<td>Prime cut kernels, per acre</td>
<td>.282 ton</td>
<td>41.8</td>
</tr>
<tr>
<td>No. 2 cans, per acre</td>
<td>25.6 cases</td>
<td>41.8</td>
</tr>
<tr>
<td>Recovery per gross ton</td>
<td>123 cans</td>
<td>22.6</td>
</tr>
</tbody>
</table>

This behavior may be explained by the fact that a single cross is much more uniform in maturity than open-pollinated strains. The total harvest of unhusked ears may be nearly the same, but the recovery of edible kernels from the single cross is much higher (41.8 percent as compared with 18.6 percent in the foregoing example) owing to the fact that there is less variation in the maturity of the cross. Therefore a ton of unhusked ears from a cross is worth more than a ton from an open-pollinated strain. The difference as shown in the above example was 22.6 percent in favor of the cross.

The fact that only relatively small increases in weights of unhusked
ears may be expected from a cross, especially in a favorable season, is explained as follows: Weight of unhusked ears depends of course on (1) the number of ears and (2) the size or weight of each ear. Under favorable conditions a good open-pollinated strain will produce about the same number and the same size of ears as the cross, and the total yields will therefore tend to be the same. However, as Huelsen and Michaels\(^9\) have pointed out, altho weights of unhusked ears are closely associated with weights of prime cut kernels, they are not an accurate means of determining the yields of prime cut kernels. Thus similarity in yields of unhusked ears does not necessarily mean equivalent recovery of cut kernels or canned corn.

**REGIONAL ADAPTABILITY OF CROSSES**

In cooperative tests over a seven-year period involving several thousand sweet-corn crosses of various types, the yield performance at Urbana frequently failed to be duplicated in northern Illinois. Many of the more promising crosses, however, were in fair agreement in the two regions.

Experience gained from these tests, as well as from actual commercial production of crosses, indicates that in order to be successful a single cross must possess a considerable range of adaptability. There is very good reason to believe that crosses which are merely local in adaptability will prove to be equally limited in adaptability to the usual changes in weather in one locality.

*Effect of Source of Seed.*—One phase of adaptability not understood at present is the effect of source of seed (region in which the seed is grown) on the performance of crosses grown from it.

Jones and Huntington,\(^11\) in discussing the relation between corn yields and climate, stated that "corn may be moved from a less favorable to a more favorable climatic region without loss of productive capacity and usually with distinct gain." Experience has shown not only that this is true, but, what is more important, that when corn is moved from a more to a less favorable climate there is a loss in productive capacity. In numerous tests at the Illinois Station sweet-corn hybrids of eastern origin have failed to produce as well as the native open-pollinated strains used for comparison. This raises the question whether the quality of a cross originating in an unfavorable climate will deteriorate by raising the seed in a more favorable section.

For the production of sweet-corn seed there are two exceptionally
favourable locations in the United States—one along Long Island Sound, in Connecticut, and the other in the Boise River Valley of Idaho, from Nampa, Idaho, northwest to Ontario, Oregon. Most of the hybrid sweet-corn seed now offered commercially is being grown in these sections.

According to personal observations by the author, radical changes in the appearance of inbreds developed in Illinois are likely to occur when they are grown in the different climates of either Idaho or Connecticut, particularly under the irrigated farming of Idaho. The changes in those grown in Connecticut were relatively slight. When inbreds originating in Illinois were brought back after only one generation in Idaho or Connecticut, the changes were very obvious. There was a definite increase in height in almost all inbreds, and some lines showed definite tendencies toward segregation altho selfed for twelve or more generations. After two generations away from Illinois these changes became more pronounced. Inbreds themselves differed widely in this respect.

The full effect of such changes in inbreds on single crosses is not now known. Long-continued tests will be necessary to determine, for example, the extent to which a single cross adapted to Illinois will maintain its drought-resistance and other desirable characters if the inbreds are grown continuously in the more favorable climate existing in the seed-producing sections of the West. Enough data on this point have been gathered, however, to point strongly to the conclusion that the crosses will deteriorate if the inbreds are grown continuously in the more favorable climate. The more progressive seedsmen have given up the idea, for the present at least, of maintaining inbreds in Idaho and Connecticut.

The effects of maintaining Illinois Country Gentleman inbreds in various sections on the yields of the crosses tested at Urbana are shown in Table 2. Yields of crosses made in Idaho from inbreds maintained there show great deterioration. The reductions were not due to outcrossing or to mixtures.

A more striking example of the effects of the favorable climate of Idaho on the yields of a single cross is shown by the results listed in Table 3. The parent inbreds of these crosses, Purdue 39 and Purdue 51, originated in Indiana. The inbreds were highly selected and carefully maintained by a good Idaho seed grower, but the yields deteriorated rapidly nevertheless, in spite of the fact that the seed for the 1934, 1935, and 1936 seed was 3, 2, and 1 year old, respectively, when tested in 1937 and 4, 3, and 2 years old when tested again in 1938.
### Table 2.—Deterioration of Illinois Country Gentleman Inbreds Maintained and Crossed in Other States and Returned to Illinois

<table>
<thead>
<tr>
<th>Cross</th>
<th>Number of years maintained away from Illinois</th>
<th>Where cross was made</th>
<th>Year tested at Urbana</th>
<th>Number of replications</th>
<th>Percent increase in weight of prime cut kernels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Over open-pollinated, Illinois grown</td>
</tr>
<tr>
<td>8 × 6</td>
<td>0</td>
<td>Illinois</td>
<td>1937</td>
<td>25</td>
<td>34.2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Connecticut</td>
<td>1937</td>
<td>5</td>
<td>30.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Idaho</td>
<td>1937</td>
<td>5</td>
<td>-6.0</td>
</tr>
<tr>
<td>8 × 6</td>
<td>3</td>
<td>Idaho</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Idaho</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td>8 × 6</td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td>5 × 10</td>
<td>0</td>
<td>Illinois</td>
<td>1937</td>
<td>5</td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Connecticut</td>
<td>1937</td>
<td>5</td>
<td>15.3</td>
</tr>
<tr>
<td>5 × 10</td>
<td>0</td>
<td>Illinois</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Idaho</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Idaho</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td>5 × 10</td>
<td>0</td>
<td>Illinois</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td>3 × 6</td>
<td>0</td>
<td>Illinois</td>
<td>1937</td>
<td>6</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Iowa</td>
<td>1937</td>
<td>5</td>
<td>-5.6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Idaho</td>
<td>1937</td>
<td>5</td>
<td>7.4</td>
</tr>
<tr>
<td>3 × 6</td>
<td>3</td>
<td>Idaho</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Iowa</td>
<td>1938</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td>3 × 6</td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Minnesota</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Idaho</td>
<td>1939</td>
<td>5</td>
<td>.....</td>
</tr>
</tbody>
</table>

*aAt the time the inbreds were released, in 1935, the lines removed from Illinois for maintenance elsewhere were identical with the respective lines continued in Illinois.*

Theoretically, such changes should not occur in a homozygous inbred line, but on the other hand it is likely that these lines are not truly homozygous. It is probable that as a result of continued selfing the line eventually becomes a mixture of pure phenotypes. Since there are no visible differences in the plants or ears to show the presence of these phenotypes, the breeder in his own trial grounds can do little or nothing to reduce their number. A radical change in climate (change in photoperiod and mean temperature) may, however, bring out these hitherto latent or invisible characters. Several examples illustrate this point.

**Examples of Latent Characters Revealed by Change of Climate.**—One example was afforded by Illinois Country Gentleman Inbred 8, which has a number of outstanding morphological characters that make
identification easy, and which is unusually uniform after seventeen
generations of inbreeding. Inasmuch as Inbred 8 has been grown for
seed on hundreds of acres in Illinois over a period of seven years, its
behavior in Illinois is understood. Only occasionally does it produce
tassel ears in Illinois. In Idaho, however, even from seed grown in
Illinois, Inbred 8 produced a large number of tassel ears. Moreover,
about 75 percent of the ears grown in Idaho had staminate inflores-
cences (rudimentary tassels) growing at the end of the cob, a char-
acter which never appears in Illinois. It was possible in 1937 to
examine for these characters corn growing from the same lot of seed

Table 3.—Progressive Deterioration in Yields of Golden Cross Bantam
Resulting from Maintaining the Inbreds in Idaho
(Averages of 5 replications with Illinois-grown checks planted every fifth row. Checks
are averages of 15 replications. All tests were made at Urbana.)

<table>
<thead>
<tr>
<th>Number of years inbreds were maintained in Idaho</th>
<th>Yields when grown in Illinois</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test in 1937</td>
</tr>
<tr>
<td>Sorted unhusked ears</td>
<td></td>
</tr>
<tr>
<td>From Illinois seed (check)*</td>
<td>...</td>
</tr>
<tr>
<td>From Idaho seed</td>
<td>3</td>
</tr>
<tr>
<td>Crossed in 1934</td>
<td>3</td>
</tr>
<tr>
<td>Crossed in 1935</td>
<td>4</td>
</tr>
<tr>
<td>Crossed in 1936</td>
<td></td>
</tr>
<tr>
<td>Prime husked ears</td>
<td>2</td>
</tr>
<tr>
<td>From Illinois seed (check)*</td>
<td>3</td>
</tr>
<tr>
<td>Crossed in 1935</td>
<td>4</td>
</tr>
<tr>
<td>Crossed in 1936</td>
<td></td>
</tr>
<tr>
<td>Prime cut kernels</td>
<td>2</td>
</tr>
<tr>
<td>From Illinois seed (check)*</td>
<td>3</td>
</tr>
<tr>
<td>Crossed in 1934</td>
<td>4</td>
</tr>
<tr>
<td>Crossed in 1935</td>
<td></td>
</tr>
</tbody>
</table>

*Seed designated as "Illinois seed" was a cross of inbred lines maintained in Illinois and crossed
the year preceding the making of the yield test.

both in Illinois and in Idaho the same season. Two seasons of selection
in Idaho were sufficient to eliminate the tassel at the end of the cob.

Another example of hidden or invisible characters being brought
out by change of climate occurred in Illinois Country Gentleman
Inbred 3 and Illinois Narrow Grain Evergreen Inbred 13. Both of
these lines have medium-length shanks when grown in Illinois, but in
Idaho they segregate for excessively long shanks.
BREEDING METHODS USED

Selection Within Inbred Lines

Description of System Used.—The principal method followed in the sweet-corn breeding program at the Illinois Station has been that known as “selection within inbred lines,” as described by Richey.13* The parent materials at the beginning of the Illinois program consisted of 200 ears of Country Gentleman and 100 ears of Narrow Grain Evergreen contributed by two canners who had grown their stocks in Illinois for several years and had used mass-selection methods. Seed from the ears was planted in individual ear-rows, yields were taken, and the conventional method of ear-row selection followed throughout the work. A duplicate planting of each row served for the purpose of inbreeding or selfing—that is, the artificial fertilization of individual ears by applying pollen from the tassel to the ear of the same plant, suitable protection being obtained by means of paper sacks. The inbred or selfed ears were planted the following year, as shown in Fig. 1. Selected plants were again selfed, and so on. Practically no sib-crossing has been used in the selection work.

The system shown in Fig. 1 is an adaptation of the old ear-row method, using selfed ears as the parents. This is a highly intensive method of breeding and is open to at least two objections. The first is that selections must be discarded very freely in order to prevent a rapid increase in the number of lines; but on the other hand there is a corresponding advantage of confining contaminations and segregations of undesirable characters to single rows where elimination is simple. The second objection is that the range of selection is narrowed by limiting the available germ plasm at the start. A possible third objection may be based on the assumption that after several generations many of the inbreds will be more or less closely related to each other.

There seems to be no one best method of carrying on a breeding program; consequently each breeder usually works out his own procedure. The method outlined in Fig. 1 gives the opportunity of intensive selection within relatively few inbred lines. In practice more new lines are selected each year out of the ear-row open-pollinated selection program which is carried on parallel to the inbreeding.

Effects of the Method on the Inbreds.—The extent to which selection within inbred lines may be carried with some prospect of improvement still remains an open question. All of the inbred lines discussed in this bulletin have been broken down into numerous sib lines,8 but

*Offspring from the same parents.
Ear-rows planted in duplicate, one planting harvested as a yield test and the duplicate rows selfed. The best selfed rows, on the basis of the yield test, carried into the next year.

Inbred ears from the highest yielding ear-rows of the first year planted in ear-rows and selfed, and the best of these, selected on the basis of appearance and ear-tests for disease and germination, carried into the third year.

Selections from previous year's planting of ear-rows planted in ear-rows and selected again in the same manner as previously.

Reciprocal crosses made between all the surviving sibs of inbred lines, only those lines being crossed that were not related to each other in any way.

Crosses tested and selected on basis of comparisons with the best open-pollinated ear-row selections carried on parallel with the inbreeding. Selections within the best-surviving inbred lines continued as before and carried on indefinitely.

Reciprocal crosses of the surviving inbred lines made in isolation plots. (For most seed growers the making of reciprocal crosses by hand is likely to be more practical than the use of isolation plots.)

Yield and quality tests of the reciprocal crosses made to eliminate finally all but the most promising inbred lines.
improvement beyond a certain point, as measured by the yield performances of the crosses, is very difficult. Continued selection within an inbred line usually improves its physical appearance and frequently the yield of seed can be materially increased. However, in the process, the yield of the cross may be seriously impaired. There are various theoretical considerations on which an explanation may be based, but this matter need not be discussed here.

The effect of selection in inbred lines on yield of the crosses is shown in Table 4. All five of the selections out of Inbred 8 were superior in appearance and vigor to the original strain, but the original release maintained for six generations in isolation gave the highest average yield for the group (97.32 percent). None of the crosses of the selections within Inbreds 8 and 6 gave yields significantly higher than that of the commercial Cross 8 × 6 used as the check.

Some of the eighty crosses of the selections within Inbreds 5 and 10 were more promising. Of the eighty, however, those from only six selections of Inbred 5 gave higher yields than the cross using the originally released Inbred 5, and of those six only three gave substantially higher yields. Thus not much progress was made toward improving the yields of the crosses by means of selection within the inbred lines. In fact, selection within inbred lines based on physical characters of plants and ears is just as likely to reduce the yields of the crosses as to increase them. The probabilities of increasing yields of crosses by such methods seem to be much more promising in a constantly varying line such as Inbred 5 than in a highly stable line such as Inbred 8. Similarly the selections within the somewhat variable Inbred 10 give better results than selections within the more stable Inbred 6.

Altho the data have been omitted from Table 4, the corn produced by each of the crosses was canned and graded, and the quality of the canned corn was just as variable as the yields. Furthermore, the corn from the higher yielding crosses was frequently sharply lower in quality than the corn from the check.

Tests such as those reported in Table 4 indicate that there is no known reliable criterion for selecting within inbred lines. Scrubby-looking selections may prove to be superior to the best-looking ones in the group. The most practical method seems to be to select both the apparently desirable and the apparently undesirable types and to check back by means of crossing and canning. This method of selection is facilitated by selfing plants individually, avoiding sib crosses so far as possible. Selfing individual plants has been followed for eighteen
<table>
<thead>
<tr>
<th>Inbred selection</th>
<th>Description</th>
<th>Number of crosses</th>
<th>Number of selections of male inbred used</th>
<th>Number of trials</th>
<th>Yields of prime cut kernels, as percent of check*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maximum and minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yield of cross using original release as male</td>
</tr>
</tbody>
</table>

**Cross 8 × 6**

<table>
<thead>
<tr>
<th>Inbred selection</th>
<th>Description</th>
<th>Number of crosses</th>
<th>Number of selections of male inbred used</th>
<th>Number of trials</th>
<th>Yields of prime cut kernels, as percent of check*</th>
</tr>
</thead>
<tbody>
<tr>
<td>8b-57</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>83.19</td>
</tr>
<tr>
<td>8c-28</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>86.45</td>
</tr>
<tr>
<td>8g-62</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>91.84</td>
</tr>
<tr>
<td>8d-59</td>
<td>Selected from 8c in P₅ crossed in P₆</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>91.84</td>
</tr>
<tr>
<td>8e-60</td>
<td>Selected from 8c in P₅ crossed in P₆</td>
<td>5</td>
<td>5</td>
<td>15</td>
<td>91.84</td>
</tr>
</tbody>
</table>

**Cross 5 × 10**

<table>
<thead>
<tr>
<th>Inbred selection</th>
<th>Description</th>
<th>Number of crosses</th>
<th>Number of selections of male inbred used</th>
<th>Number of trials</th>
<th>Yields of prime cut kernels, as percent of check*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maximum and minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yield of cross using original release as male</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inbred selection</th>
<th>Description</th>
<th>Number of crosses</th>
<th>Number of selections of male inbred used</th>
<th>Number of trials</th>
<th>Yields of prime cut kernels, as percent of check*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a-272</td>
<td>Original release (P₉)</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>98.68</td>
</tr>
<tr>
<td>5d-277</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>6</td>
<td>6</td>
<td>15</td>
<td>100.99</td>
</tr>
<tr>
<td>5e-34</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>11</td>
<td>106.88</td>
</tr>
<tr>
<td>5f-35</td>
<td>Selected from 5e in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>93.72</td>
</tr>
<tr>
<td>5g-36</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>100.99</td>
</tr>
<tr>
<td>5h-37</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>98.04</td>
</tr>
<tr>
<td>5i-38</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>112.00</td>
</tr>
<tr>
<td>5k-39</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>117.29</td>
</tr>
<tr>
<td>5l-40</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>98.40</td>
</tr>
<tr>
<td>5m-41</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>103.89</td>
</tr>
<tr>
<td>5p-43</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>11</td>
<td>69.30</td>
</tr>
<tr>
<td>5q-44</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>83.27</td>
</tr>
<tr>
<td>5r-45</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>67.19</td>
</tr>
<tr>
<td>5s-46</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>82.05</td>
</tr>
<tr>
<td>5t-292</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>76.67</td>
</tr>
<tr>
<td>5v-47</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>69.63</td>
</tr>
<tr>
<td>5w-48</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>130.41</td>
</tr>
<tr>
<td>5x-49</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>109.46</td>
</tr>
<tr>
<td>5y-50</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>86.22</td>
</tr>
<tr>
<td>5z-51</td>
<td>Ear selection in P₅ crossed in P₆</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>59.81</td>
</tr>
</tbody>
</table>

*Check was Cross 8 × 6, commercially grown and produced in the same section of Illinois where the individual inbreds were crossed.

**Released in 1933 and maintained in isolation plots in Illinois by a commercial seed grower.**
generations at the Illinois Station. The data in Table 4 show that the
degree of homozygosity attained so far as the quantitative genes are
concerned is not very high—that for Inbred 5, for example, is very low
indeed.

Selfing of Desirable Crosses

Theoretically, if Cross A × B is selfed, the resulting inbreds will
have the good qualities of either A or B predominating, plus a portion
of those contributed by the other parent.

In actual practice numerous crosses have been selfed for as many
as twelve generations, and the resultant inbred lines have resembled
one or the other of the parents without showing any superiority as
determined by yields in a series of crosses. In view of the disappoint-
ing results, this method of breeding has not been included in the system
of breeding outlined in Fig. 1.

Back-Crossing

Continuous back-crossing has also been followed, using Narrow
Grain Evergreen Inbred 14 as the pollinator. Even tho very diverse
material was used, including Country Gentleman, the results are of
questionable value, as there is no evidence that any of the back crosses
when used as parents in single crosses were superior to the original
Inbred 14 in yield performance.

Possible Deterioration in Inbred Lines

The system of inbreeding outlined in the foregoing paragraphs has
one defect in common with all the other methods which have been
proposed—there is no certainty that a high level of yield and quality
once established by inbreeding can be maintained.

Experience has shown that inbred lines reach their prime after
about ten generations of selfing. If a line inbred to that extent fails
to give good crosses, it is certain that no amount of further selection
will change this performance. In a line which does cross well, it is
equally certain by the laws of chance alone, that slight improvements
can be effected, but that they cannot go on indefinitely.

From the way in which inbreds in general behave, there would
seem to be a slight tho constant decrease in vigor in successive gener-
ations, which will most likely affect the crosses sooner or later. From
their behavior in crosses, there is reason to believe that inbred lines
have a period of development followed by one of senescence.
Most breeders are aware of this danger of deterioration. Various methods of sib-crossing have been proposed to forestall possible deterioration, but there is no proof so far that such procedures are any more successful than the constant selfing, selection, and testing of crosses previously discussed.

Since knowledge of inbred behavior is so slight, the advisable course seems to consist in constant selection followed by sib-crossing in the multiplication plots and the crossing of selections within inbred lines with similar selections in the paired inbred. There is considerable evidence that the behavior of inbred selections, such as those in Table 4, can be materially changed by pairing selections. In other words, certain selections will nick better than others. It may be possible by such methods to maintain productiveness and quality in the crosses, but there is no positive proof of this at the present time.

WHAT CONSTITUTES A GOOD INBRED LINE

Two criteria are used in determining the value of an inbred: it must produce well, and it must give desirable crosses. If an inbred is low-yielding but gives superior crosses, it must be used as the pollen parent; and it therefore needs to have good tassel characters. A familiar example is \( P_{39} \times P_{51} \) (Golden Cross Bantam), in which \( P_{51} \), because of low seed yields, is always used as the pollen parent.

Two low-yielding inbreds may produce a high-yielding cross, but because of the high seed cost such a combination has little commercial value. The ideal cross would seem to be a combination of two high-yielding inbreds, but in actual practice the best combinations usually consist of a highly desirable inbred line combined with one more or less mediocre, the latter serving as the pollen parent.

In propagating pairs of inbreds such as these, the breeder is tempted to "improve" the mediocre line by selection. Results such as those in Table 4 will most likely follow unless adequate precautions are taken.

TWELVE INBRED LINES RELEASED

As the result of the breeding work outlined in the foregoing sections, certain inbred lines have proved to be consistently superior when used in single crosses. The yield trials on which these conclusions are based and a description of the crosses are given in Table 5 and on pages 326 to 352. Eight Country Gentleman and four Narrow Grain
Evergreen inbred lines have been released to several seedsmen under certain restrictions. The released lines are as follows:

<table>
<thead>
<tr>
<th>Illinois Country Gentleman</th>
<th>Number of generations inbred, thru 1939</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbred 1</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 3</td>
<td>15</td>
</tr>
<tr>
<td>Inbred 5</td>
<td>15</td>
</tr>
<tr>
<td>Inbred 6</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 10</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 8</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 9</td>
<td>15</td>
</tr>
<tr>
<td>Inbred 15</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Illinois Narrow Grain Evergreen</th>
<th>Number of generations inbred, thru 1939</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbred 11</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 13</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 14</td>
<td>17</td>
</tr>
<tr>
<td>Inbred 55</td>
<td>15</td>
</tr>
</tbody>
</table>

Crosses between these lines were first made in 1928, since which time certain combinations have come into commercial use in Illinois and elsewhere.

Inbred 9, originally released, was dropped later, as it proved to be inferior to the sib-line 8, and Inbreds 1 and 15 have been withdrawn from commercial production. The eight lines of Country Gentleman were crossed in all possible combinations, barring those that were related. These crosses were tested for yield and canning quality in 1933 and 1934, two very unfavorable drouth years, at Urbana and in northern Illinois. Only the Urbana results are discussed here, inasmuch as the data obtained in northern Illinois supported conclusions similar to those based on the Urbana data.

The tests were conducted on a dark prairie silt loam of moderate fertility which was manured the previous fall. No commercial fertilizers were used. A medium amount of phosphorus was available. The crosses were planted at random, 38 by 38 inches apart in 1933 and 40 by 40 inches in 1934. Each plot consisted of 20 hills in a single row, with checks planted every fifth row. No attempt was made to correct for the border effect, which cannot be avoided with single rows. However, since the crosses did not differ materially in plant size, the border effect could not have been very significant. That the border effect was not very significant was indicated further by the fact that the results of the northern Illinois tests, which were on a three-row basis per plot, with only the center row being harvested, led to the same conclusions.

Five replications were planted each year, but owing to adverse weather in 1933 one or more replications of many of the crosses had to be discarded because of poor stand. In 1934 the tests were repeated with the same lots of seed, and owing to better conditions in the spring practically no plots were discarded because of stand.
The plots were planted 4 to 5 kernels per hill and thinned down to 3 as soon as the seedlings reached a height of 4 inches. The checks were planted with seed obtained from the highest yielding strain out of open-pollinated ear-row selections continuously selected since 1922. Only the most perfect ears were used for planting the checks, the choice being made on the bases of appearance and the results of testing each ear in a germinator for viability and freedom from rots and molds. Such ears were butted and tipped before shelling, but were not run thru a grader. The hybrid seed was merely shelled without butting or tipping and without testing in the germinator. The experimental bias was therefore strongly against the hybrids, which had to be very vigorous indeed to overcome this initial handicap.

The corn was harvested in a single picking from each row at the prime canning stage. All the ears were snapped and sorted later into usable ears and culls. The usable unhusked ears were husked in a husking machine and were again sorted into prime canning ears and nonusable ears, which are called "husked culls." The prime husked ears were then run thru a Sprague No. 5 corn-cutter and the weights recorded in terms of cream-style cut.

**Results of Yield Tests With Single Crosses**

The yield tests for 1933 and 1934 at Urbana were averaged (Table 5) and the increases in yields over the nearest checks were compared without making any other corrections for soil heterogeneity. The significance of the mean increases in yields were determined according to the methods described in Chapter V of Fisher's work on statistical methods. Comparisons of two mean differences were made on the basis of the formula stated by Burgess:

$$S.E.\text{-M.D.} = \sqrt{\left(\frac{S.E.^2}{n}\right)_a + \left(\frac{S.E.^2}{n}\right)_b}$$

Probability was determined from the value $t$ according to Table IV of Fisher's work. Mean differences were not considered significant when the values of $P$ exceeded .05.

Many of the crosses yielded significantly more than the checks (Table 5). These differences were used as the basis for selecting the crosses to be propagated commercially.

The crosses listed in Table 5 were paired as far as possible with their reciprocals. Many of the pairs themselves showed significant differences in yield. These differences have been critically analyzed.
Table 5.—Acre-Yields of Country Gentleman Single Crosses and of Open-Pollinated Country Gentleman Checks: Two-Year Averages, 1933-1934

(The value of $t$ was determined by dividing the mean increases by the respective standard errors, and was used to determine the significance of the results, designated by $P$, according to Fisher’s Table IV.** Where the value of $P$ is .05 or lower, the difference is regarded as being significant. Values lower than .05 indicate higher degrees of significance.)

| Cross | Degrees of freedom | Unhusked ears | | Husked prime ears | | Husked culls | | Prime cut kernels |
|-------|-------------------|---------------|-----------------|-------------------|-----------------|-------------------|-------------------|
|       |                   | Mean increase | Variance | $t$ | $P$ | Mean increase | Variance | $t$ | $P$ | Mean increase | Variance | $t$ | $P$ | Mean increase | Variance | $t$ | $P$ |
|       |                   | over check    |          |     |     | over check    |          |     |     | over check    |          |     |     | over check    |          |     |     |
| $2 \times 1$ | 8 | -0.525 | .149 | 2.603 | .05 | -0.01 | .053 | .270 | .8 | -0.09 | .024 | 1.882 | .1 | -0.02 | .051 | 513 | .7 |
| $1 \times 2$ | 9 | -0.450 | .246 | 2.702 | .05 | -0.035 | .030 | .607 | .6 | -0.132 | .042 | 1.940 | .1 | -0.052 | .050 | 1.282 | .3 |
| Difference |       | 0.125 | .622 | .6 | .056 | .593 | .6 | .033 | .397 | .7 | .073 |               |          |     |     |               |          |
| $3 \times 1$ | 8 | -1.69 | .488 | 3.726 | .5 | .404 | .164 | 3.000 | .02 | -0.108 | .028 | 1.944 | .1 | -0.127 | .031 | 2.158 | .1 |
| $1 \times 3$ | 8 | 2.80 | .325 | 1.480 | .2 | .214 | .112 | 1.908 | .1 | .081 | .022 | 1.646 | .2 | .046 | .040 | 7.03 | .6 |
| Difference |       | -1.11 | .370 | .8 | .190 | .102 | .3 | .189 | .370 | .7 | .081 |               |          |     |     |               |          |
| $4 \times 1$ | 7 | -2.94 | .232 | 3.770 | <.01 | -0.226 | .084 | 2.212 | .1 | -0.127 | .023 | 2.352 | .1 | -0.064 | .021 | 1.240 | .3 |
| $1 \times 4$ | 8 | -4.32 | .166 | 3.177 | .02 | -0.065 | .027 | 1.189 | .3 | -0.12 | .016 | 2.896 | .02 | -0.055 | .011 | 1.582 | .2 |
| Difference |       | -2.09 | .961 | .4 | -1.61 | .134 | .2 | -0.066 | .091 | .9 | -0.009 |               |          |     |     |               |          |
| $5 \times 1$ | 8 | 1.334 | .300 | 4.148 | <.01 | .837 | .107 | 7.689 | <.01 | -0.100 | .027 | 1.830 | .2 | -0.244 | .045 | 3.465 | <.01 |
| $1 \times 5$ | 8 | 6.28 | .257 | 3.713 | <.01 | .333 | .046 | 4.681 | <.01 | -0.127 | .043 | 1.836 | .2 | -0.064 | .016 | 1.512 | .2 |
| Difference |       | 7.06 | .280 | .02 | .504 | .397 | .02 | -0.027 | .104 | .7 | -0.180 |               |          |     |     |               |          |
| $6 \times 1$ | 8 | 2.20 | .283 | 1.238 | .3 | .295 | .135 | 2.404 | .05 | .004 | .01 | 1.010 | >.9 | -0.068 | .028 | 1.213 | .3 |
| $1 \times 6$ | 8 | 4.69 | .493 | 2.004 | .1 | .548 | .190 | 3.773 | <.01 | -0.034 | .042 | 1.200 | .7 | -0.142 | .018 | 3.209 | .02 |
| Difference |       | 2.49 | .850 | .5 | -2.53 | 1.514 | .2 | -0.048 | .495 | .7 | -0.074 |               |          |     |     |               |          |
| $7 \times 1$ | 7 | -0.06 | .192 | .387 | .8 | .113 | .112 | .961 | .4 | -0.062 | .055 | .114 | .5 | -0.023 | .020 | .458 | .7 |
| $1 \times 7$ | 7 | .05 | .317 | .295 | .8 | -1.49 | .158 | 1.065 | .4 | -0.004 | .071 | .044 | >.9 | -0.068 | .043 | .923 | .4 |
| Difference |       | -1.19 | .047 | .9 | .262 | 1.433 | .2 | -0.058 | .460 | .7 | -0.091 |               |          |     |     |               |          |
| $8 \times 1$ | 7 | .987 | .311 | 5.005 | <.01 | .794 | .224 | 4.042 | <.01 | -0.007 | .076 | .074 | >.9 | -0.353 | .047 | 4.615 | <.01 |
| $1 \times 8$ | 7 | .471 | .353 | 2.379 | .05 | .422 | .170 | 3.064 | .02 | -0.039 | .010 | 1.169 | .3 | -0.162 | .017 | 3.651 | <.01 |
| Difference |       | .516 | .814 | .5 | .372 | 1.718 | .2 | -0.032 | .310 | .8 | -0.191 |               |          |     |     |               |          |
| $9 \times 1$ | 8 | 0.475 | .371 | 2.341 | .05 | .611 | .324 | 3.221 | .02 | -0.037 | .042 | .543 | .7 | -0.256 | .075 | 2.803 | .05 |
| $1 \times 9$ | 8 | .302 | .267 | 1.755 | .2 | .381 | .158 | 2.884 | .05 | .081 | .036 | 1.287 | .3 | -0.120 | .026 | 2.231 | .1 |
| Difference |       | .173 | .650 | .6 | .230 | .994 | .4 | .044 | .476 | .7 | -0.136 |               |          |     |     |               |          |
| $10 \times 1$ | 8 | .487 | .367 | 2.406 | .05 | .595 | .109 | 5.400 | <.01 | -0.071 | .033 | 1.166 | .3 | -0.211 | .023 | 4.218 | <.01 |
| $1 \times 10$ | 8 | .450 | .431 | 2.055 | .1 | .469 | .134 | 3.841 | <.01 | -0.014 | .042 | 2.100 | .9 | -0.161 | .026 | 3.000 | .02 |
| Difference |       | .037 | .124 | .9 | .126 | .764 | .5 | -0.057 | .618 | .5 | -0.050 |               |          |     |     |               |          |
| Cross       | Degrees of freedom | Unhusked ears |        |        |    |        |        |        |    |        |        |  |    |    |        |        |    |    |    |        |        |    |    |    |        |        |
|------------|--------------------|---------------|--------|--------|----|--------|--------|--------|----|--------|--------|  |    |    |--------|--------|----|----|----|--------|--------|----|----|----|--------|--------|
|            |                    | Mean increase | Variance | t     | P  | Mean increase | Variance | t     | P  | Mean increase | Variance | t  | P  | Mean increase | Variance | t  | P  | Mean increase | Variance | t  | P  |
| OP x 1     | 8                  | .178          | .129    | 1.488 | .2 | .316          | .106     | 2.913 | .02| -.045         | .020     | 950 | .4 | .092          | .026     | 1.695 | .1 |               |          |
| 1 x 15     | 8                  | -.250         | .129    | 2.093 | .1 | .095          | .038     | 1.460 | .2 | -.128         | .032     | 2.131 | .1 | .034          | .008     | 1.166 | .3 |               |          |
| 1 x 16     | 8                  | -.445         | .241    | 2.717 | .05| .016          | .149     | 1.28  | >.9| -.167         | .032     | 2.817 | .05| .010          | .035     | .165  | .9 |               |          |
| 3 x 2      | 8                  | -.313         | .141    | 10.919| <.01| -.036         | .029     | .616  | .6 | -.079         | .014     | 2.026 | .1 | -.068         | .015     | 1.692  | .2 |               |          |
| 2 x 3      | 8                  | -.237         | .183    | 1.663 | .2 | .062          | .034     | 1.010 | .4 | -.113         | .012     | 3.081 | .02| -.005         | .005     | .225  | .9 |               |          |
| Difference |                    | -.076         | .402    | .008  | .3 | .008          | .170     | .3    | .034 | .629          | .6       | .063  | .3 |               |          |       |    |               |          |
| 4 x 2      | 8                  | -.858         | .185    | 5.981 | <.01| -.437         | .029     | 2.574 | .05| -.100         | .018     | 2.251 | .1 | -.158         | .011     | 4.448  | <.01|               |          |
| 2 x 4      | 8                  | -.802         | .118    | 7.005 | .1 | -.402         | .071     | 5.523 | <.01| -.115         | .014     | 2.955 | .02| -.127         | .007     | 4.618  | <.01|               |          |
| Difference |                    | -.056         | .303    | .008  | .7 | .055          | .518     | .7    | .015 | .026          | >.9      | .011  | .5 |               |          |       |    |               |          |
| 5 x 2      | 8                  | .250          | .118    | 2.190 | .1 | .210          | .077     | 2.272 | .1 | -.215         | .070     | 2.44  | .9 | .067          | .010     | 2.009  | .1 |               |          |
| 2 x 5      | 8                  | -.186         | .360    | .927  | .4 | -.127         | .134     | 1.042 | .4 | .009          | .011     | 2.74  | .8 | -.113         | .034     | 1.836  | .2 |               |          |
| Difference |                    | -.436         | 1.393   | .1    | .337 | .205          | .05     | 2.24  | .2 | .224          | .005     | 2.572 | .05|               |          |       |    |               |          |
| 6 x 2      | 5                  | -.252         | .512    | .860  | .5 | .040          | .283     | .138  | .9 | .050          | .018     | .928  | .4 | -.020         | .052     | .208   | .9 |               |          |
| 2 x 6      | 6                  | -.331         | .263    | 1.706 | .2 | .006          | .121     | .452  | .7 | -.165         | .014     | 4.119 | <.01| -.075         | .024     | .851   | .5 |               |          |
| Difference |                    | .079          | .226    | .9    | .9 | .040          | .118     | .9    | .115 | .177          | .2       | .000  | .5 |               |          |       |    |               |          |
| 7 x 2      | 6                  | -.348         | .227    | 1.946 | .2 | -.168         | .112     | 1.328 | .3 | -.116         | .009     | 3.249 | .02| -.838         | .024     | 1.419  | .3 |               |          |
| 2 x 7      | 7                  | -.475         | .260    | 2.639 | .05| .216          | .060     | 2.495 | .05| -.067         | .015     | 1.516 | .2 | -.115         | .019     | 2.329  | .05|               |          |
| Difference |                    | .127          | .498    | .7    | .048 | .316          | .8      | .049  | .4 | .872          | .4       | .723  | .4 |               |          |       |    |               |          |
| 8 x 2      | 7                  | -.210         | .381    | .096  | >.9| .138          | .116     | .720  | .5 | -.109         | .042     | 1.521 | .2 | .046          | .028     | .787   | .5 |               |          |
| 2 x 8      | 8                  | -.492         | .356    | .248  | .9 | .030          | .138     | .245  | .9 | -.077         | .015     | 1.918 | .1 | -.021         | .036     | .332   | .8 |               |          |
| Difference |                    | .283          | .956    | .4    | .108 | .626          | .6      | .032  | .8 | .387          | .8       | .067  | .4 |               |          |       |    |               |          |
| 9 x 2      | 8                  | -.336         | .392    | 1.610 | .2 | .098          | .148     | .764  | .5 | -.064         | .022     | 1.280 | .3 | -.081         | .029     | 1.428  | .2 |               |          |
| 2 x 9      | 8                  | -.306         | .303    | 1.669 | .2 | .119          | .155     | 1.142 | .3 | -.147         | .022     | 3.013 | .02| -.093         | .035     | 1.485  | .2 |               |          |
| Difference |                    | .030          | .108    | .9    | .247 | .1348         | .2      | .083  | .2 | 1.200         | .3       | .012  | .9 |               |          |       |    |               |          |
| 10 x 2     | 7                  | -.295         | .343    | 1.420 | .2 | -.116         | .161     | .820  | .5 | -.064         | .019     | 1.299 | .3 | -.082         | .039     | 1.177  | .3 |               |          |
| 2 x 10     | 7                  | -.232         | .371    | 1.076 | .4 | -.303         | .131     | .237  | .9 | -.091         | .050     | 1.151 | .3 | -.041         | .057     | .493   | .7 |               |          |
| Difference |                    | .063          | .210    | .9    | .187 | .977          | .4      | .027  | .8 | .268          | .8       | .041  | .8 |               |          |       |    |               |          |

(Table 5 continued on following page)
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Classification of Crosses

Classification Based on Selectivity.—On the basis of the characteristics of their parents, the single crosses listed in Tables 5, 6, and 7 fell into three classes: compatible, incompatible, and antagonistic. Compatible crosses are those which are made in the proper direction with selective inbred lines, that is, a selective female by a selective male. Incompatible crosses are those made in the wrong direction, that is, a selective male inbred line used as a female by a selective female inbred used as a male. Antagonistic crosses are made between similarly selective parents, that is, a selective male by a selective male, or a selective female by a selective female.

The basis for making such a classification is the data in Table 5 grouped and averaged according to parental lines in Table 6. According to Table 6, Inbreds 1, 2, 4, 6, and 10 all showed more or less tendency to be selectively male. In Inbreds 1 and 6 this tendency was statistically significant with regard to certain yield components.

Inbreds 3, 5, 7, 8, and 9, on the other hand, tended to be selectively female, Inbreds 5, 7, and 9 significantly so in certain instances, assuming that for a large number of degrees of freedom any value of $t$ as great as or exceeding 1.95996 is significant, since according to Fisher's this value is equivalent to the 5-percent point where $n = \infty$. It should be noted that Inbreds 6 and 10, closely related lines, are both selectively male, while Inbreds 8 and 9, also related, are selectively female.

Yields of compatible and antagonistic crosses are given in Table 7. The increases in yields were computed from the differences in yield between the reciprocal crosses recorded in Table 5. These differences were then listed in two groups—compatible and antagonistic. The following example shows how the computations were made, using the yields of cut kernels of Inbred 8, which is selectively female:

$$
\begin{align*}
\text{Compatible Crosses (Inbred 8 used as female)} & \quad \text{Antagonistic Crosses (Inbred 8 used as female with a selective female used as a male)} \\
8 \times 1 \text{ greater than } 1 \times 8 \text{ by } & \quad 8 \times 3 \text{ greater than } 3 \times 8 \text{ by } \ldots & = & -0.070 \\
8 \times 2 \text{ greater than } 2 \times 8 \text{ by } & \quad 8 \times 5 \text{ greater than } 5 \times 8 \text{ by } \ldots & = & -0.040 \\
8 \times 4 \text{ greater than } 4 \times 8 \text{ by } & \quad 8 \times 7 \text{ greater than } 7 \times 8 \text{ by } \ldots & = & 0.057 \\
8 \times 6 \text{ greater than } 6 \times 8 \text{ by } & \quad \quad & = & \text{Mean} = -0.018 \pm 0.036 \\
8 \times 10 \text{ greater than } 10 \times 8 \text{ by } & \quad & = & -0.052 \\
& \quad \quad \text{Mean} = & = & 0.055 \pm 0.036 \\
\end{align*}
$$

The difference between the compatible and antagonistic crosses in this example equals $0.073 \pm 0.051$ ($t = 1.431$) tons.

The results, according to the data listed in Table 7, were somewhat irregular, and in addition nearly all the values of $t$ were too small to
Table 6.—Performance of Country Gentleman Inbreds When Used as Male and When Used as Female Parents, as Determined by Increases in Acre-Yields of Crosses Over Open-Pollinated Checks: Two-Year Averages, 1933-1934
(The value $t$ was determined by dividing the mean increases by the respective standard errors)

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<th>Inbred line</th>
<th>Degrees of freedom</th>
<th>Ear component</th>
<th>Mean increases, inbred used as male</th>
<th>$t$</th>
<th>Mean increases, inbred used as female</th>
<th>$t$</th>
<th>Difference between increases, male over female&lt;sup&gt;a&lt;/sup&gt;</th>
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(Table 6 concluded on following page)
### Table 6.—(Concluded)

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<td>Culls, husked</td>
<td>-0.084</td>
<td>4.199</td>
<td>-0.052</td>
<td>2.943</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cut kernels</td>
<td>-0.036</td>
<td>1.589</td>
<td>0.086</td>
<td>3.763</td>
</tr>
<tr>
<td>10</td>
<td>146</td>
<td>Unhusked ears</td>
<td>0.073</td>
<td>3.841</td>
<td>0.014</td>
<td>1.888</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prime husked ears</td>
<td>-0.232</td>
<td>3.984</td>
<td>0.197</td>
<td>3.824</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Culls, husked</td>
<td>0.073</td>
<td>3.558</td>
<td>-0.084</td>
<td>4.418</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cut kernels</td>
<td>0.064</td>
<td>2.564</td>
<td>0.062</td>
<td>2.910</td>
</tr>
</tbody>
</table>

*The standard errors of the mean increases were calculated according to the formula $\frac{1}{N} \sqrt{\left(\frac{s^2}{n}\right)_a + \left(\frac{s^2}{n}\right)_b + \left(\frac{s^2}{n}\right)_c + \ldots + \left(\frac{s^2}{n}\right)_x}$ in which $N$ is the total number of reciprocal crosses compared, $s^2$ is the variance and $n$ the number of replications. The same result may be obtained by adding together the squares of the standard errors, taking the square root, and dividing by $N$. The formula used is the shorter method, as the standard error is calculated from the formula

$$\sqrt{\frac{s^2}{n}}$$

which is equivalent to $\frac{\sigma}{\sqrt{n}}$.

The values of $t$ were obtained by dividing the mean differences by the standard error.

Negative numbers in this column mean that the yield increases over the check were greater when the inbred was used as female than when it was used as male.

*Significant differences.
<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Mean increase in yields of compatible crosses</th>
<th>Standard error</th>
<th>t</th>
<th>Mean increase in yields of incompatible crosses</th>
<th>Standard error</th>
<th>t</th>
<th>Difference, compatible minus incompatible crosses</th>
<th>Standard error</th>
<th>t</th>
<th>Unlinked ears</th>
<th>Husked ears</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.124</td>
<td>0.148</td>
<td>1.944</td>
<td>0.113</td>
<td>0.099</td>
<td>1.310</td>
<td>0.074</td>
<td>0.091</td>
<td>0.811</td>
<td>2.336</td>
<td>1.872</td>
</tr>
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<td>2</td>
<td>0.028</td>
<td>0.030</td>
<td>1.230</td>
<td>0.026</td>
<td>0.025</td>
<td>1.358</td>
<td>0.001</td>
<td>0.033</td>
<td>0.030</td>
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<td>0.765</td>
</tr>
<tr>
<td>3</td>
<td>0.007</td>
<td>0.006</td>
<td>0.139</td>
<td>0.007</td>
<td>0.006</td>
<td>0.198</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.654</td>
<td>0.665</td>
</tr>
<tr>
<td>4</td>
<td>0.001</td>
<td>0.002</td>
<td>0.113</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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<tr>
<td>5</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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<tr>
<td>6</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
</tr>
<tr>
<td>7</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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<tr>
<td>8</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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<tr>
<td>9</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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<tr>
<td>10</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.001</td>
<td>0.001</td>
<td>0.133</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.308</td>
<td>0.308</td>
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</table>

(Table continued on following page)
<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Mean increases in yields of indicated compatible crosses</th>
<th>Standard error</th>
<th>t</th>
<th>Mean increases in yields of indicated antagonistic crosses</th>
<th>Standard error</th>
<th>t</th>
<th>Difference, compatible over antagonistic crosses*</th>
<th>Standard error</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...........</td>
<td>- .040</td>
<td>.044</td>
<td>.909</td>
<td>.002</td>
<td>.040</td>
<td>.050</td>
<td>- .042</td>
<td>.060</td>
<td>.700</td>
</tr>
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<td>2...........</td>
<td>- .038</td>
<td>.033</td>
<td>1.152</td>
<td>.031</td>
<td>.038</td>
<td>.816</td>
<td>- .069</td>
<td>.050</td>
<td>1.380</td>
</tr>
<tr>
<td>3...........</td>
<td>- .046</td>
<td>.050</td>
<td>.920</td>
<td>- .009</td>
<td>.046</td>
<td>1.96</td>
<td>- .037</td>
<td>.068</td>
<td>.544</td>
</tr>
<tr>
<td>4...........</td>
<td>- .062</td>
<td>.050</td>
<td>1.240</td>
<td>.069</td>
<td>.042</td>
<td>1.643</td>
<td>- .131*</td>
<td>.065</td>
<td>2.015</td>
</tr>
<tr>
<td>5...........</td>
<td>- .069</td>
<td>.038</td>
<td>1.816</td>
<td>.017</td>
<td>.056</td>
<td>.304</td>
<td>- .086</td>
<td>.067</td>
<td>1.284</td>
</tr>
<tr>
<td>6...........</td>
<td>- .009</td>
<td>.036</td>
<td>.250</td>
<td>- .094</td>
<td>.041</td>
<td>2.293</td>
<td>.085</td>
<td>.055</td>
<td>1.345</td>
</tr>
<tr>
<td>7...........</td>
<td>- .054</td>
<td>.040</td>
<td>1.350</td>
<td>.016</td>
<td>.046</td>
<td>.348</td>
<td>- .070</td>
<td>.061</td>
<td>1.148</td>
</tr>
<tr>
<td>8...........</td>
<td>.001</td>
<td>.035</td>
<td>.029</td>
<td>- .045</td>
<td>.051</td>
<td>.882</td>
<td>.046</td>
<td>.061</td>
<td>.754</td>
</tr>
<tr>
<td>9...........</td>
<td>- .005</td>
<td>.031</td>
<td>.161</td>
<td>.015</td>
<td>.045</td>
<td>.333</td>
<td>- .020</td>
<td>.055</td>
<td>.364</td>
</tr>
<tr>
<td>10..........</td>
<td>- .024</td>
<td>.030</td>
<td>.800</td>
<td>- .008</td>
<td>.045</td>
<td>1.78</td>
<td>- .016</td>
<td>.054</td>
<td>.296</td>
</tr>
</tbody>
</table>

**Cults, husked**

1........... | .136                                                   | .041           | 3.317 | .010                                                     | .033           | .303 | .126*                                            | .052           | 2.423 |
| 2........... | - .105                                                 | .033           | 3.182 | - .028                                                   | .043           | .651 | - .077                                           | .054           | 1.426 |
| 3........... | .015                                                   | .029           | .517 | .013                                                     | .043           | .302 | .002                                            | .052           | .038  |
| 4........... | .001                                                   | .029           | .034 | .027                                                     | .032           | .844 | .026                                            | .043           | .605  |
| 5........... | .079                                                   | .033           | 2.394 | .020                                                     | .048           | .417 | .059                                            | .058           | 1.017 |
| 6........... | .048                                                   | .034           | 1.412 | .025                                                     | .041           | .610 | .023                                            | .054           | 1.434 |
| 7........... | - .122                                                 | .035           | 3.486 | - .029                                                   | .046           | .630 | .093                                            | .057           | 1.632 |
| 8........... | .055                                                   | .036           | 1.528 | - .018                                                   | .036           | .500 | .073                                            | .051           | 1.431 |
| 9........... | .072                                                   | .038           | 1.895 | .024                                                     | .040           | .600 | .048                                            | .055           | .873  |
| 10.......... | .022                                                   | .033           | .667 | - .034                                                   | .044           | .773 | .056                                            | .055           | 1.018 |

**Prime cut kernels**

*Significant differences.

*Negative numbers mean that the mean yield increases of the cross over the checks were greater when the cross was antagonistic than when it was compatible.
show significant differences. The inconsistencies were due to Inbreds 2, 4, and 7, all of which have been discarded because of low yields (Table 5). Many of the comparisons involving these three inbreds were between decreases rather than increases in yields, as compared with the yields of the open-pollinated checks.

The other seven inbreds, however, were consistent in their tendencies, agreeing with field experience in making these crosses on a commercial scale.

On a genetic basis crosses and their reciprocals should be the same. Aside from considerations of seed quality discussed by Ashby\(^1\), \(^2\)* and Sprague,\(^1\)\(^7\)* the yields should be approximately equal. The data in Tables 5, 6 and 7 indicate, however, that the plant breeder is justified in assuming that crosses and their reciprocals will not give the same performance. In numerous instances reciprocal crosses differed significantly in yields (Table 5), a tendency confirmed by observations made on a large number of additional crosses.

Possible Causes for Differences in Yields of Reciprocals.—Many of the differences in the yields of reciprocals in Table 5 may be ascribed to physiological causes. For instance, in crossing an inbred susceptible to ear rots with one partially resistant, reciprocals would be expected to show yield differences, inasmuch as one cross would produce seed having a high initial infection, whereas the other would be relatively free.

Differences in seed size undoubtedly explain some of the yield differences between reciprocal crosses. Thus when it is used as the seed parent, Inbred 6, which has extremely small kernels, produces a weaker plant and lower yield and matures later than its reciprocal (Table 12, page 320). This is in accordance with Ashby’s\(^1\)\(^3\)* third postulate, that reciprocal crosses differing in embryo weight should differ in degree of vigor. Sprague,\(^1\)\(^7\)* using later generations of Ashby’s material, was able to substantiate this postulate only partially, finding that seed having small embryos was later in maturity than that having large embryos, but that the growth rate was not significantly different. In the work reported here (Table 5) the differences in yield were not, however, due to differences in maturity. Differences in maturity were compensated by harvesting at the same relative canning stage, using silk counts as the basis, according to methods described by Huelsen and Michaels.\(^8\)*

In order to determine further whether size of seed of Inbred 6 is the factor involved in producing lower yields, a reciprocal cross was made in Idaho in 1938 between Inbreds 8 and 6 because when Inbred
6 is grown there the kernels are considerably larger and freer from disease than when produced in Illinois. The reciprocal crosses were tested in 1939 at Urbana in five trials paired with Cross 8 × 6 as the check grown from seed produced in Illinois. The mean weights, expressed as percentages of the check, were:

<table>
<thead>
<tr>
<th></th>
<th>Cross 8 × 6</th>
<th>Cross 6 × 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorted unhusked ears</td>
<td>81.45</td>
<td>66.78</td>
</tr>
<tr>
<td>Prime husked ears</td>
<td>79.37</td>
<td>65.45</td>
</tr>
<tr>
<td>Prime cut kernels</td>
<td>77.27</td>
<td>61.11</td>
</tr>
</tbody>
</table>

Cross 6 × 8 was thus again consistently lower in yield than Cross 8 × 6. Something besides size of seed probably is involved.

*Reasons for Selectivity of Inbreds.*—The tendency for Inbreds 1, 2, 4, and 10 (Table 6) to be selectively male cannot, however, be explained satisfactorily on the basis of seed size, none of them having the abnormally small kernels which characterize Inbred 6. In fact Inbred 4 is selectively male in spite of having excellent seed quality and poor tassels. Inbred 10, which is closely related to Inbred 6 but has larger kernels, is also selectively male without a satisfactory explanation. Inbred 1 is selectively male perhaps because, as explained later, it has weak germination due to some unknown factor.

In the selectively female group (Table 6), Inbreds 3 and 5 have poor tassels, which may have something to do with their preference; but in contrast Inbreds 8 and 9 which are closely related have exceptionally good tassels. Inbreds 5, 8, and 9 have large seed, but Inbred 3 has relatively small seed.

It is quite obvious in view of these facts that the selectivity of an inbred is a matter to be seriously considered by the breeder. The data are insufficient, however, to determine whether selectivity is due to individual strain peculiarities, or to response to some law of genetics or physiology. The evidence from these experiments points in the direction of strain idiosyncrasy.

**Selectivity of Inbreds in Relation to the Breeding Program**

The significant yield differences between reciprocal crosses (Table 5) show that an inbred can be properly evaluated only when its selectivity as to male or female use is definitely known. Selectivity can be determined by making a series of reciprocal crosses and comparing the yields (Table 6).

The most successful crosses are compatible, and the breeder can save considerable time by limiting his crossing program to this type.
Antagonistic and incompatible crosses should in general be avoided, altho certain exceptions will undoubtedly appear. For example, Cross 1 × 6, which is antagonistic since both inbreds are selectively male, was used commercially and was dropped only because of consistently poor germination. Cross 3 × 8 is another antagonistic cross having commercial value, but it is not as good as certain others in the group and was finally dropped in 1938.

EVALUATING ILLINOIS COUNTRY GENTLEMAN INBREDS

The inbred lines discussed in this bulletin (both the Country Gentleman inbreds, and the Narrow Grain Evergreen inbreds discussed on pages 322 to 326) were first evaluated on the basis of physical characters, yields, and uniformity, but as soon as approximate hemozygosity was attained, their usefulness had to be determined. In other words, potential value had to be converted into actual value by performance as parents in crosses. Actual value can best be determined by crossing an inbred line with a series of others and averaging the performance of the crosses.

Evaluation on Basis of Yields

The levels of performance of the inbred lines were calculated by averaging the yield increases over their respective open-pollinated checks of all the crosses, including reciprocals, in which each inbred was used as a parent. The mean increases thus obtained are a measure of the productivity of a given inbred in crosses and have been consistently used in the sweet-corn breeding work at the Illinois Station.

After calculating the mean increases for each inbred it was possible to make direct comparisons of inbreds with each other (Table 8, see footnote b).

Inbreds 2, 4, 7, and 16 are obviously poorer than the others as indicated by the preponderance of minus signs in their respective columns in Table 8. With the exception of husked culls Inbred 4 showed no increases, indicating that its performance was the poorest of any of the inbreds. Inbreds 2, 7, and 16 were not quite as poor as Inbred 4, but it will be noted under their respective columns in Table 8 that the only increases recorded were over one or more of the other inbreds in this group of four low yielders (Inbreds 2, 4, 7, and 16).

The inferior performance of the top crosses is shown in Table 8 under the column headed “open pollinated.” Except for husked culls
Table 8.—Performance of Country Gentleman Inbreds as Determined by Averaging the Mean Increases of the Crosses, Including Reciprocals, Over the Respective Checks and Subtracting the Resulting Means: Two-Year Averages, 1930-1934

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Increase in yield of each inbred specified below over each inbred indicated in column at leftb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Tons unhulled ears per acre</td>
</tr>
<tr>
<td></td>
<td>1.484*</td>
</tr>
<tr>
<td>1.484*</td>
<td></td>
</tr>
<tr>
<td>2.484*</td>
<td></td>
</tr>
<tr>
<td>3.158*</td>
<td></td>
</tr>
<tr>
<td>3.158*</td>
<td></td>
</tr>
<tr>
<td>4.841*</td>
<td></td>
</tr>
<tr>
<td>4.481*</td>
<td></td>
</tr>
<tr>
<td>5.195*</td>
<td></td>
</tr>
<tr>
<td>6.082</td>
<td></td>
</tr>
<tr>
<td>7.339</td>
<td></td>
</tr>
<tr>
<td>8.099</td>
<td></td>
</tr>
<tr>
<td>9.085</td>
<td></td>
</tr>
<tr>
<td>10.134</td>
<td></td>
</tr>
<tr>
<td>15*</td>
<td></td>
</tr>
<tr>
<td>16*</td>
<td></td>
</tr>
<tr>
<td>Top cross</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tons unhusked ears per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.484*</td>
</tr>
<tr>
<td>1.484*</td>
</tr>
<tr>
<td>2.484*</td>
</tr>
<tr>
<td>3.158*</td>
</tr>
<tr>
<td>3.158*</td>
</tr>
<tr>
<td>4.841*</td>
</tr>
<tr>
<td>4.481*</td>
</tr>
<tr>
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<td>9.085</td>
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<td>10.134</td>
</tr>
<tr>
<td>15*</td>
</tr>
<tr>
<td>16*</td>
</tr>
<tr>
<td>Top cross</td>
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</table>
### Table 8.—(Concluded)

<table>
<thead>
<tr>
<th>Inbred</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>15</th>
<th>16</th>
<th>Open-pol-(\text{inated}^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons prime cut kernels per acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
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<td>.139*</td>
<td>.043*</td>
<td>.200*</td>
<td>.009</td>
<td>.007</td>
<td>.099*</td>
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<td>.013</td>
<td>.012</td>
<td>.027</td>
<td>.089*</td>
<td>.032</td>
</tr>
<tr>
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<td>.096*</td>
<td>.096*</td>
<td>.061*</td>
<td>.157*</td>
<td>.034</td>
<td>.050</td>
<td>.056*</td>
<td>.064*</td>
<td>.030</td>
<td>.031</td>
<td>.066*</td>
<td>.004</td>
<td>.030</td>
</tr>
<tr>
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<td>.130*</td>
<td>.034</td>
<td>.191*</td>
<td>.016</td>
<td>.090*</td>
<td>.030</td>
<td>.004</td>
<td>.003</td>
<td>.065*</td>
<td>.003</td>
<td>.094*</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>.007</td>
<td>.146*</td>
<td>.050</td>
<td>.207*</td>
<td>.016</td>
<td>.106*</td>
<td>.014</td>
<td>.020</td>
<td>.019</td>
<td>.001</td>
<td>.063</td>
<td>.066*</td>
<td></td>
</tr>
<tr>
<td>5.</td>
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<td>.160*</td>
<td>.064*</td>
<td>.221*</td>
<td>.030</td>
<td>.120*</td>
<td>.086*</td>
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<td>.069*</td>
<td>.022</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>.013</td>
<td>.126*</td>
<td>.030</td>
<td>.187*</td>
<td>.004</td>
<td>.020</td>
<td>.086*</td>
<td>.034</td>
<td>.001</td>
<td>.076*</td>
<td>.014</td>
<td>.090*</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>.012</td>
<td>.121*</td>
<td>.031</td>
<td>.188*</td>
<td>.003</td>
<td>.019</td>
<td>.087*</td>
<td>.033</td>
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</tr>
<tr>
<td>8.</td>
<td>.007</td>
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<td>.065*</td>
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<td>.014</td>
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<td>9.</td>
<td>.089*</td>
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<td>.139*</td>
<td>.094*</td>
<td>.066*</td>
<td>.022</td>
<td>.103*</td>
<td>.090*</td>
<td>.071*</td>
<td>.092*</td>
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<tr>
<td>11*</td>
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<td>.139*</td>
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<td>.071*</td>
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<td>.030</td>
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<tr>
<td>Top cross(c)</td>
<td>.032</td>
<td>.073*</td>
<td>.030</td>
<td>.139*</td>
<td>.094*</td>
<td>.066*</td>
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<td>.103*</td>
<td>.090*</td>
<td>.071*</td>
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<tr>
<td>Tons husked culls per acre</td>
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<tr>
<td>1.</td>
<td>.042*</td>
<td>.042*</td>
<td>.051*</td>
<td>.060*</td>
<td>.037</td>
<td>.044*</td>
<td>.045*</td>
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<td>.032</td>
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<td>.009</td>
<td>.018</td>
<td>.079*</td>
<td>.002</td>
<td>.003</td>
<td>.036</td>
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<td>.062*</td>
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<td>3.</td>
<td>.060*</td>
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<td>.079*</td>
<td>.088*</td>
<td>.097</td>
<td>.081*</td>
<td>.082*</td>
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<td>.082*</td>
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<td>.005</td>
<td>.035*</td>
<td>.055*</td>
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<tr>
<td>11*</td>
<td>.060*</td>
<td>.048</td>
<td>.028</td>
<td>.116*</td>
<td>.026</td>
<td>.096*</td>
<td>.030</td>
<td>.041</td>
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<tr>
<td>12*</td>
<td>.083*</td>
<td>.062*</td>
<td>.042</td>
<td>.130*</td>
<td>.040</td>
<td>.053</td>
<td>.076*</td>
<td>.044</td>
<td>.055*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top cross(c)</td>
<td>.008</td>
<td>.052*</td>
<td>.051*</td>
<td>.057*</td>
<td>.040</td>
<td>.036</td>
<td>.019</td>
<td>.003</td>
<td>.018</td>
<td>.018</td>
<td>.059*</td>
<td>.073*</td>
<td></td>
</tr>
</tbody>
</table>

*Mean increases significant and 1 more than twice the standard error, the number of varieties ranging from 329 to 371 in comparisons between Inbreds 1 to 10 inclusive and from 161 to 212 where Inbreds 1 to 10 are compared with Inbreds 15 and 16 and as top crosses.

1Inbreds 15 and 16 were used only as males in the crosses which were tested and when their yields are compared with those of Inbreds 1 to 10 only the yields of the crosses in which Inbreds 1 to 10 are also used as males have entered into the computations.

2The increases for the inbred designated at the top of each column were calculated as follows: (1) the differences in yield between all the crosses including reciprocals, in which the inbred was used as a parent, and the respective open-pol-linated checks were averaged; (2) the mean differences thus obtained were directly compared with similar mean differences calculated in the same way for the other inbreds. Thus Inbred 1 was compared with all the remaining inbreds indicated in the first column at the left and the differences between the respective mean differences recorded and their significance calculated.

3Open-pol-linated strain of Country Gentileman used as female in top crosses with Inbreds 1 to 10 inclusive, 15 and 16. The yields of Inbreds 1-10 used as females are the only ones entering into the comparison. For lines 15 and 16 only the yields where the inbreds were used as males are available, and were used.
the only increases were over the four lowest yielding inbreds, namely Inbreds 2, 4, 7, and 16.

The performance of Inbred 3 was also very mediocre, practically the only increases being over the inferior Inbreds 2, 4, 7, and 16, and the top crosses. Inbred 3 was not discarded, however, as were Inbreds 2, 4, 7, and 16, but was retained because in certain limited combinations it proved to have some value.

The remaining lines, Inbreds 1, 5, 6, 8, 9, 10, and 15, all showed more or less promise (Table 8), as indicated by the small number of significant decreases in their respective columns.

Mean differences such as those in Table 8 are also useful in calling attention to gene characters which are transmitted to the crosses, evidently being dominant because of their appearance in the F₁ generation. For instance, Inbreds 5 and 8 showed a strong tendency to produce large yields of unhusked ears but a relatively low recovery of cut kernels, a fact which has been substantiated by their performance in numerous additional crosses.

In contrast, Inbred 15 (Table 8) gave a high recovery of cut kernels, as indicated by the preponderance of increases in yields of prime cut kernels, and a relatively low yield of unhusked ears, as shown by the numerous minus signs in that column. This characteristic of Inbred 15 has been checked in numerous additional crosses both experimental and commercial.

These differences in yield performance show the danger of attempting to determine the value of crosses or of inbreds on the basis of data on only a single yield component. The value of the different yield components as bases for evaluating inbreds is discussed in the next section.

The data in Table 8 are open to criticism because reciprocals are included even tho it has been shown that the lines are either selectively male or selectively female. The yields were also compared as far as possible with reciprocals eliminated, but the results are not given here, inasmuch as they do not change the conclusions reached from the data as given in Table 8.

Relative Values of Various Yield Components.—The yield characteristics of the crosses in which the several inbreds were used as parents are further analyzed in Table 9 for the purpose of determining the relative values of the various yield components as a basis for judging the performance of inbred lines. According to Table 9, the percentage differences between prime cut kernels and prime husked ears were small and only three of them were significant. On the other
Table 9.—Relative Performance of Inbred Lines Determined by Averaging the 1934 Mean Yields of Each Cross in Which the Respective Inbreds Appeared as Parents and Comparing Them by Yield Components
(The value \( t \) was determined by dividing the mean increases by the respective standard errors)

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>Degrees of freedom</th>
<th>Prime husked ears compared with unhusked ears</th>
<th>Prime cut kernels compared with prime husked ears</th>
<th>Prime cut kernels compared with unhusked ears</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean difference*</td>
<td>( t )</td>
<td>Mean difference*</td>
<td>( t )</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>28.39</td>
<td>5.91*</td>
<td>2.97</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>14.40</td>
<td>3.36*</td>
<td>1.50</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>28.48</td>
<td>7.76*</td>
<td>-5.70</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>3.63</td>
<td>1.11</td>
<td>-2.09</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>21.90</td>
<td>4.67*</td>
<td>-10.28</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>34.55</td>
<td>6.84*</td>
<td>- .19</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>17.39</td>
<td>5.24*</td>
<td>- .14</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>20.98</td>
<td>6.01*</td>
<td>1.50</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
<td>24.24</td>
<td>5.96*</td>
<td>1.05</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
<td>29.58</td>
<td>7.13*</td>
<td>-10.90</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>39.76</td>
<td>7.54*</td>
<td>.72</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>38.82</td>
<td>7.66*</td>
<td>.84</td>
</tr>
<tr>
<td>Top cross*</td>
<td>11</td>
<td>19.42</td>
<td>4.77*</td>
<td>-5.51</td>
</tr>
</tbody>
</table>

*Values of \( t \) indicate \( P \) is less than .05, hence difference is significant.
*The differences between the mean yields of the five replications of each cross and their respective checks were calculated as percentages of the checks (check = 100 percent). These percentages were averaged on the basis of the parents; that is to say, all the crosses in which Inbred 1, for example, was a parent were averaged together. The same thing was done with the other inbreds. The mean percentages for each inbred were then compared in three groups as shown (prime husked ears with sorted unhusked ears, et cetera) and the mean differences between these percentages recorded in the proper columns. The direction which these mean percentage differences take is indicated by the column headings, the first stated component greater than the last (prime husked ears greater sorted unhusked, et cetera).
*Open-pollinated strain used as female parent in twelve top crosses.

hand, the differences between prime cut kernels and unhusked ears were large, and all but one were significant. This is interpreted to mean that the weights of prime cut kernels can be estimated with much greater accuracy from the weights of prime husked ears than from the weights of sorted unhusked ears. Similarly the large significant differences between weights of prime husked and sorted unhusked ears indicate that the yield of the latter component may not be used to predict the yield of the former. These results with crosses parallel the conclusions reached by Huelsen and Michaels\(^*\) in work with open-pollinated varieties of sweet corn.

Relative Percentages of Recovery and Waste.—Only the data for 1934 on relative percentages of recovery and waste are given (Table 10), as the 1933 figures do not change the conclusions. Because 1933 and 1934 were very severe drought years, the base (normal recovery of open-pollinated Country Gentleman sweet corn) given in Table 10 is higher than the recovery of the open-pollinated Country Gentleman checks. Altho the performance of the inbreds was also
### TABLE 10.—RELATIVE PERCENTAGES OF RECOVERY AND WASTE OF COUNTRY GENTLEMAN INBREDS USED IN SINGLE CROSSES, 1934

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>Number of crosses averaged*</th>
<th>1 ton unhusked ears = 100 percent</th>
<th>1 ton prime husked ears = 100 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prime husked ears</td>
<td>Husks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>perct.</td>
<td>perct.</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>55.90</td>
<td>44.10</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>51.78</td>
<td>48.22</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>51.26</td>
<td>48.74</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>42.96</td>
<td>57.04</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>49.03</td>
<td>50.97</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>58.10</td>
<td>41.90</td>
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<td>53.34</td>
<td>46.66</td>
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<td>18</td>
<td>55.95</td>
<td>44.05</td>
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<td>57.23</td>
<td>42.78</td>
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<td>41.67</td>
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<td>10</td>
<td>59.39</td>
<td>40.61</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>59.69</td>
<td>40.31</td>
</tr>
<tr>
<td>Top cross*</td>
<td>12</td>
<td>52.33</td>
<td>47.67</td>
</tr>
<tr>
<td>Checks*</td>
<td>(*)</td>
<td>41.56</td>
<td>58.44</td>
</tr>
</tbody>
</table>

* Each cross replicated five times.
* Open-pollinated Country Gentleman used as the female in top crosses with the twelve inbreds listed.
* Open-pollinated Country Gentleman used as checks; averages of 100 replications.
* The base is the normal performance of open-pollinated Country Gentleman sweet corn in Illinois. See Huelsen and Michaels. 9

below par, only Inbred 4 gave as low a percentage of prime husked ears as the open-pollinated checks.

Prime cut kernels (basis: weight of prime husked ears = 100 percent, Table 10) were relatively uniform compared with the other yield components. This further indicates that if accurate yield records of sweet-corn crosses are desired, the yields of the edible portion of the ear must be the basis of comparison. From the genetic standpoint the relative uniformity of this yield component is important because it indicates that none of the inbred lines deviate very much from open-pollinated sweet corn in weight of cobs. Individual crosses do, of course, show considerable variation in this respect.

The prime husked ears and prime cut kernels (basis: weight of unhusked ears = 100 percent, Table 10) both showed wide variations due mostly to the large differences in the percentages of husks, thus further confirming the unreliability of yields of unhusked ears as a basis for estimating other yield components. According to Huelsen and Michaels, 9 the best way to determine the yield of prime cut kernels is to actually secure the cut-off records, tho the yields of prime husked ears of the open-pollinated varieties with which that work was done were in sufficiently close correlation to serve commercially as a basis
for prediction purposes. In these studies of inbreds and crosses the relative yields of prime husked ears and of prime kernels differed significantly (Table 9) in three of thirteen inbred lines. It is doubtful, therefore, whether inbreds can be evaluated with sufficient accuracy on any other basis than yields of cut kernels.

**Evaluation on Basis of Quality**

Yield should not be the only basis for evaluating inbred lines and crosses. Quality is equally important. A really successful cross combines high yield with high quality.

*Method of Classification.*—In these experiments quality was measured by means of actual canning tests conducted in cooperation with one of the Illinois canning companies. Since defects in quality in the Country Gentleman variety are most evident when it is packed whole-grain style, this was the style of cut used. In 1933, corn from each of the crosses was packed in 12-ounce cans with brine, but in 1934 the vacuum pack with only a small addition of brine was used.

The canned corn was sampled during the winters of 1933-34 and 1934-35 according to the then current commercial practice. The samples were rated on the following points, the sequence of the numbers showing the order of preference:

**Color**

1. White (not due to over-maturity)  
2. Trace of brown  
3. Slightly brown (slightly dark)  
4. Brown (dark) .................. Color acceptable  
5. Gray  
6. Yellow tinged  
7. Yellow caps  

**Flavor**

1. Excellent  
2. Very good  
3. Good  
4. Fair  
5. Poor  
6. Very poor

**Toughness**

1. Very tender (extra fancy)  
2. Tender (fancy)  
3. Fairly tender (fancy minus)  
4. Slightly tough (extra standard)  
5. Tough (standard)  
6. Very tough (substandard)

**Width of kernels**

1. Very small  
2. Small  
3. Medium-small  
4. Medium  
5. Medium-large  
6. Large

**Length of kernel (depth of cut)**

1. Very deep  
2. Deep  
3. Good  
4. Medium-good  
5. Medium  
6. Medium-shallow  
7. Shallow
The commercial grades of canned corn (extra fancy, fancy, extra standard, standard, and substandard) were determined for each cross but are not discussed inasmuch as the purpose of the study was to determine the nature of any inherent defects associated with the inbreds and crosses.

Results.—Two to four lots of each cross were canned in 1933, but in 1934 only the more promising crosses were canned, and those were canned in duplicate. The frequency distributions of the readings are given in Table 11. These should be regarded merely as indicative, because in packing a large number of small samples errors due to differences in maturity and slight variations in the method of packing were bound to occur even tho all possible precautions were taken. Maturities were estimated on the basis of silk counts and the corn was harvested accordingly.

The discrepancies in total numbers of samples of the same inbred in the different sections of Table 11 (for example, 21 samples of Inbred 1 were tested for color and 39 for flavor) were due to the fact that for some samples no reading was taken of certain characters because of defects due apparently to variation in the method of packing. The much lower totals recorded under the color readings in 1933 were due to the elimination of replicate samples and the recording of only the best reading of each group. It is assumed that when the corn is packed from four replicates of a cross, the sample showing the best color is the one most truly representative.

None of the inbreds showed conspicuously uniform color defects. Especially in 1933 some crosses showed a tinge of yellow, an undesirable character in Country Gentleman sweet corn. The white color of some of the samples was not due to over-maturity.

As to flavor, all of the inbreds produced crosses which in 1933 had flavor lower than “good,” but in this respect they were no worse than open-pollinated Country Gentleman. None of the inbreds except Inbred 4 could be singled out on the basis of flavor. Inbred 4 had a distinctive popcorn-like flavor different from that of any other Country Gentleman line.

Several inbreds could be singled out on the basis of pericarp character (Table 11). Crosses in which Inbreds 4, 6, 8, and 15 were used had a noticeably tender pericarp. None of the inbreds, however, consistently produced tough crosses, altho some of them, Inbreds 1 and 2 for example, produced a considerable number of tough crosses in 1933.

In kernel character the inbreds showed wide differences (Table 11). Inbreds 4, 6, and 10 produced predominantly slender kernels, but none
| Inbred | Frequency 1933 | | | | | | Total samples | Frequency 1934 | Remarks |
|--------|---------------|---|---|---|---|---|---|---|---|---|
|        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1.     | 21 | 3 | 12 | 3 | 1 | . | . | 2 | 21 | 2 | 8 | 10 | 1 | . | . |
| 2.     | 20 | 7 | 8 | 1 | 1 | . | . | 3 | 13 | 1 | 7 | 5 | 1 | . | . |
| 3.     | 19 | 5 | 11 | . | . | . | . | 3 | 22 | 2 | 8 | 11 | 1 | . | . |
| 4.     | 21 | 9 | 11 | . | . | . | . | 3 | 13 | 2 | 8 | 3 | 1 | . | . |
| 5.     | 21 | 6 | 10 | 3 | 2 | . | . | 2 | 20 | 2 | 9 | 9 | . | . | . |
| 6.     | 21 | 7 | 12 | 5 | . | . | . | 1 | 18 | 4 | 5 | 9 | . | . | . |
| 7.     | 21 | 9 | 7 | 5 | . | . | . | 2 | 12 | . | 8 | 4 | . | . | . |
| 8.     | 20 | 9 | 10 | 1 | . | . | . | 1 | 18 | 4 | 10 | 4 | . | . | . |
| 9.     | 20 | 9 | 8 | 3 | . | . | . | 2 | 12 | 6 | 4 | . | . | . | . |
| 10.    | 21 | 10 | 8 | 2 | 1 | . | . | 3 | 18 | 3 | 9 | 1 | 2 | . | . |
| 11.    | 11 | 7 | 3 | 1 | . | . | . | 4 | 10 | 3 | 5 | 1 | . | 1 | . |
| 12.    | 11 | 6 | 3 | 2 | . | . | . | 5 | 1 | 3 | 1 | . | . | . | . |
| Top crossb | 12 | 1 | 10 | 1 | . | . | . | . | . | . | . | . | . | . | . |
|        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Color  | Good color | Good color | Good color | Good color | Excellent color | Good color | Good color | Good color | Excellent color | Good color | Good color | Good color | Fair to good color | Good color | Good color |
| Flavor | Distinctive flavor |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|        | Unusually tender | Tender | Tender | Unusually tender |     |     |     |     |     |     |     |     |     |     |     |     |

(Table 11 concluded on following page)
### Table 11.—(Concluded)

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Frequency 1933</th>
<th>Frequency 1934</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total samples</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1a</td>
<td>2</td>
</tr>
<tr>
<td>Width of kernels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>38</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>2.</td>
<td>35</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>3.</td>
<td>32</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>4.</td>
<td>41</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>5.</td>
<td>36</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>6.</td>
<td>37</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>7.</td>
<td>38</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>8.</td>
<td>35</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>9.</td>
<td>34</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>10.</td>
<td>32</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>15.</td>
<td>19</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>16.</td>
<td>21</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Top crossb.</td>
<td>22</td>
<td>1</td>
<td>13</td>
</tr>
</tbody>
</table>

| Length of kernels |
|-------------------|---------------|---------------|---------|
| 1.                 | 38            | 2 | 10 | 13 |    | 12 | 1 |    | 21           | 9 | 10 | 2 |    |    |    |    |    |
| 2.                 | 35            | 1 | 5 | 6 | 1 | 17 | 5 |    | 13           | 4 | 6 | 2 | 1 |    |    |    |    |
| 3.                 | 32            | 4 | 7 |    | 14 | 6 | 22 |    | 6           | 11 | 1 | 1 |    |    |    |    |    |
| 4.                 | 41            | 1 | 4 | 25 | 11 | 13 | 1 |    | 13           | 1 | 10 | 1 |    |    |    |    |    |
| 5.                 | 36            | 1 | 2 | 11 | 15 | 6 | 22 |    | 3           | 15 | 4 |    |    |    |    |    |    |
| 6.                 | 37            | 1 | 10 | 8 | 14 | 4 | 19 |    | 8           | 3 |    |    |    |    |    |    |    |
| 7.                 | 38            | 1 | 3 | 27 | 7 | 12 | 1 |    | 8           | 3 |    |    |    |    |    |    |    |
| 8.                 | 35            | 2 | 9 | 15 | 1 | 5 | 18 |    | 12           | 2 | 4 |    |    |    |    |    |    |
| 9.                 | 35            | 2 | 10 | 1 | 13 | 9 | 12 |    | 3           | 5 | 4 |    |    |    |    |    |    |
| 10.                | 32            | 6 | 12 | 1 | 6 | 7 | 18 |    | 2           | 11 | 3 | 2 |    |    |    |    |    |
| 15.                | 26            | 2 | 6 | 2 | 9 | 1 | 10 | 6 | 2 | 3 | 2 |    |    |    |    |    |
| 16.                | 21            | 2 | 3 | 10 | 6 | 4 |    |    | 3           | 1 |    |    |    |    |    |    |    |
| Top crossb.        | 22            | 3 | 4 | 3 | 10 | 1 | 1 | 6 |    | 4 | 2 |    |    |    |    |    |    |

*These column headings correspond to the grade or quality numbers listed on page 315.
bOpen-pollinated Country Gentleman used in top crosses.
was characterized by unusually wide kernels. Kernel length ranged mostly from medium to good, but all the lines produced some crosses having deep kernels and other crosses having shallow kernels. In none of them did "deep kernels" constitute the modal class. The relatively wide spread in kernel depth indicates that this character, if hereditary, is probably only partially dominant. For instance, Inbred 1, which has long kernels, produced one cross in 1933 having shallow kernels, but Inbred 6, which also has long kernels, produced four crosses having shallow kernels. On the other hand Inbred 4, which has shallow kernels, produced in 1933 a total of five crosses having "good" or "deep" kernel depth.

The frequencies for 1933 listed in Table 11 are of value, however, in indicating the strain tendencies, which may be summarized as follows:

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Percent of crosses deeper than medium</th>
<th>Percent of crosses deeper than medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbred 1</td>
<td>65.8</td>
<td>Inbred 3</td>
</tr>
<tr>
<td>Inbred 10</td>
<td>59.4</td>
<td>Inbred 2</td>
</tr>
<tr>
<td>Inbred 6</td>
<td>51.4</td>
<td>Inbred 9</td>
</tr>
<tr>
<td>Inbred 15</td>
<td>50.0</td>
<td>Inbred 16</td>
</tr>
<tr>
<td>Top crosses</td>
<td>45.4</td>
<td>Inbred 4</td>
</tr>
<tr>
<td>Inbred 5</td>
<td>41.7</td>
<td>Inbred 7</td>
</tr>
<tr>
<td>Inbred 8</td>
<td>40.0</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation on Basis of Maturity**

Maturity was estimated on the basis of silk counts, by the method described by Huelsen and Michaels. The relative lengths of time from planting to maturity of the inbreds (averages of crosses in which the inbreds were used) in comparison with the respective open-pollinated checks are given in Table 12.

Most of the inbreds were earlier than the checks, but it should be noted that here again the various strains were selective according to their use, many being earlier when used in compatible crosses. Inbreds 2, 3, 5, 6, 8, and 9 all showed this trend. Since compatibility was determined by the yield, it follows that with these six inbreds good yields and earliness were associated. In Inbreds 5, 6, 8, and 9 this trend may have been due to a third factor, seed size. Inbreds 5, 8, and 9 are selectively female and have large seed; and Inbred 6 is selectively male, and has very small seed. In Inbreds 2 and 3 the gains in earliness were slight and, moreover, not consistent. Inbreds 4 and 10 gave contradictory results. Inbreds 1 and 7, of which the incompatible crosses were the earlier, showed a trend contrary to that shown by Inbreds 2, 3, 5, 6, 8, and 9.
Table 12.—Comparative Time to Maturity of Inbred Lines Used in Crosses, Measured by Mean Number of Days Earlier or Later* Than Respective Open-Pollinated Checks, 1933-1934

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>1933</th>
<th>1934</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>days</td>
<td>days</td>
</tr>
<tr>
<td>1</td>
<td>-.44</td>
<td>1.38</td>
</tr>
<tr>
<td>2</td>
<td>.10</td>
<td>.10</td>
</tr>
<tr>
<td>3</td>
<td>-.73</td>
<td>-.67</td>
</tr>
<tr>
<td>4</td>
<td>-.38</td>
<td>-1.00</td>
</tr>
<tr>
<td>5</td>
<td>-.80</td>
<td>.62</td>
</tr>
<tr>
<td>6</td>
<td>-.30</td>
<td>-1.40</td>
</tr>
<tr>
<td>7</td>
<td>-1.60</td>
<td>-1.90</td>
</tr>
<tr>
<td>8</td>
<td>-.27</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>.30</td>
<td>3.00</td>
</tr>
<tr>
<td>10</td>
<td>-1.90</td>
<td>-1.30</td>
</tr>
<tr>
<td>15</td>
<td>-.27</td>
<td>-.82</td>
</tr>
<tr>
<td>16</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>Top crossb</td>
<td>-.58</td>
<td>....</td>
</tr>
</tbody>
</table>

*Minus sign means earlier. The fractions of days were secured by averaging the number of days between planting and mid-silking for all the replicated plots of at least twenty crosses, except for Inbreds 15 and 16 and the open-pollinated checks, where ten to twelve crosses or replicates were averaged. The means thus calculated were subtracted from the mean number of days obtained from the accompanying checks.

bOpen-pollinated Country Gentleman used in top crosses.

Apparently seed size is an important factor involved in the time required for maturing. Accordingly, it would seem advisable when making crosses in actual practice, to use the larger-seeded parent as the seed parent so far as possible. This practice would tend to increase the earliness of maturity, but not necessarily the yields.

Evaluation on Basis of Individual Ear Weights

Weight per husked ear is an important factor in evaluating the crosses produced by any inbred line, as even a small increase here will afford a substantial saving in manufacturing costs. The performance of the several inbred lines in these studies with respect to mean weights per prime husked ear is given in Table 13. Performance was calculated on the basis of use in crosses, there being substantial differences in some cases according to whether the inbred was used as male or as female.

Inbreds 1, 2, 6, 8, and 10 which, with the exception of Inbred 8, were selectively male (Table 6), produced, on the average, larger ears when used as male parents. In contrast, Inbreds 5, 7, and 9, all selectively female, had larger ears on the average when used as seed parents. Inbreds 3 and 4 showed no such differences. Annual results were not always in agreement with these average tendencies.

These observations further confirm previous conclusions regarding
TABLE 13.—MEAN* WEIGHS PER PRIME HUSKED EAR, PERCENTAGE BASIS
(Weight of check-plot ears = 100 percent)

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>1933 Used as female</th>
<th>1934 Used as female</th>
<th>Average Used as female</th>
<th>1933 Used as male</th>
<th>1934 Used as male</th>
<th>Average Used as male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>perc.</td>
<td>perc.</td>
<td>perc.</td>
<td>perc.</td>
<td>perc.</td>
<td>perc.</td>
</tr>
<tr>
<td>1</td>
<td>109.2</td>
<td>113.8</td>
<td>111.2</td>
<td>111.3</td>
<td>110.2</td>
<td>112.5</td>
</tr>
<tr>
<td>2</td>
<td>91.6</td>
<td>91.9</td>
<td>86.4</td>
<td>100.8</td>
<td>89.0</td>
<td>96.4</td>
</tr>
<tr>
<td>3</td>
<td>101.1</td>
<td>99.7</td>
<td>99.2</td>
<td>102.0</td>
<td>100.2</td>
<td>100.8</td>
</tr>
<tr>
<td>4</td>
<td>86.1</td>
<td>90.8</td>
<td>85.4</td>
<td>80.4</td>
<td>86.0</td>
<td>85.6</td>
</tr>
<tr>
<td>5</td>
<td>110.5</td>
<td>107.7</td>
<td>108.7</td>
<td>105.9</td>
<td>109.6</td>
<td>106.8</td>
</tr>
<tr>
<td>6</td>
<td>105.1</td>
<td>104.2</td>
<td>103.3</td>
<td>107.6</td>
<td>104.2</td>
<td>105.9</td>
</tr>
<tr>
<td>7</td>
<td>98.7</td>
<td>96.5</td>
<td>97.3</td>
<td>92.5</td>
<td>98.0</td>
<td>94.5</td>
</tr>
<tr>
<td>8</td>
<td>100.4</td>
<td>102.1</td>
<td>98.8</td>
<td>99.9</td>
<td>99.6</td>
<td>101.0</td>
</tr>
<tr>
<td>9</td>
<td>102.6</td>
<td>98.7</td>
<td>98.0</td>
<td>96.0</td>
<td>100.3</td>
<td>97.4</td>
</tr>
<tr>
<td>10</td>
<td>96.2</td>
<td>103.1</td>
<td>102.6</td>
<td>105.1</td>
<td>99.4</td>
<td>104.1</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>104.6</td>
<td></td>
<td>106.6</td>
<td></td>
<td>105.6</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>88.8</td>
<td></td>
<td>91.5</td>
<td></td>
<td>90.2</td>
</tr>
<tr>
<td>Top cross</td>
<td>100.2</td>
<td></td>
<td>109.2</td>
<td></td>
<td>104.7</td>
<td></td>
</tr>
</tbody>
</table>

*The mean percentages are averages of at least 10 crosses each replicated five times and compared with an equal number of checks. Each percentage is therefore the mean of at least 50 plots. The weight per ear for each plot was calculated by dividing the total weight of prime husked ears by the total number of such ears produced.

Open-pollinated Country Gentleman used in top crosses.

selectivity of inbred lines. In general the larger ears are associated with compatible crosses.

Evaluation on Basis of Smut Frequency

Since from the canner's viewpoint smut is highly objectionable on ears of sweet corn, inbreds which are susceptible to smut must be used in crosses only with caution. Five of the inbreds (Inbreds 2, 6, 7, 10, and 16) showed considerable smut in these tests, and in addition the frequency of smut on the top crosses was high (Table 14). Inbred 9 showed an exceptionally small percentage of smut, and Inbreds 4, 5, 8, and 15 showed slightly higher amounts. The latter five strains may therefore be considered relatively free from this disease, especially as there was practically no severe smut in crosses utilizing any of them.

General Evaluation of Inbred Lines

The performance of the inbred lines both as to yield and as to quality is summarized in Table 15. Inbreds 2, 7, and 9 did not have a great deal to recommend them in comparison with some of the others. Inbred 4, altho low in yield, was exceptional in the quality of its crosses, the canned corn being characterized by a flavor very similar to that of freshly roasted popcorn, quite unlike any other Country Gentleman strain. Inbreds 6 and 10 were acceptable in spite of their
Table 14.—Number of Plots on Which Evidences of Smut Were Found on Husked Ears out of Crosses, Classified by Inbred Lines, 1934

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>Number of plots observed*</th>
<th>Number of plots where smut was—</th>
<th>Total plots on which smut was observed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Slight</td>
<td>Considerable</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>120</td>
<td>19</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>2.</td>
<td>120</td>
<td>16</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>3.</td>
<td>120</td>
<td>18</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>4.</td>
<td>120</td>
<td>13</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>5.</td>
<td>120</td>
<td>13</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>6.</td>
<td>120</td>
<td>21</td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td>7.</td>
<td>120</td>
<td>23</td>
<td>13</td>
<td>36</td>
</tr>
<tr>
<td>8.</td>
<td>110</td>
<td>13</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>9.</td>
<td>110</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>10.</td>
<td>120</td>
<td>20</td>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>15.</td>
<td>55</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>16.</td>
<td>55</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Top crossb</td>
<td>55</td>
<td>14</td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>

*Each cross was replicated five times and the total number of plots involved is the number of crosses X 5. “Slight smut” means that only a few ears in each plot were infected; “considerable smut” means that the percentage of ears having smut was high.

bOpen-pollinated Country Gentleman used in top crosses.

susceptibility to smut, but in using them care must be taken to cross them with relatively smut-free types.

Top crosses with open-pollinated Country Gentleman did not compare favorably with crosses from most of the inbred lines, and consequently the use of such top crosses is not considered acceptable.

The canning quality of the inbreds as determined by use in crosses did not show much variation, according to Table 15. None of the inbreds in the group had consistently poor quality. It should be understood in this connection that this group of inbreds was selected from more than a hundred lines, as those having the most promise. Poor quality would have been indicated by underlying defects in the preliminary tests made to select the better inbreds. Inasmuch as the quality ratings in Table 15 are summaries, individual crosses may of course be much higher or much lower in quality than indicated there.

**NARROW GRAIN EVERGREEN INBREDS AND CROSSES**

Discussion of Narrow Grain Evergreen inbreds in this bulletin is limited to four lines (Inbreds 13 and 14 released in 1935 and Inbreds 11 and 55 released in 1939) which have proved to be the best in a considerable group of Narrow Grain Evergreen strains. Since in Illinois this variety has become of relatively minor importance in comparison with Country Gentleman, it is not considered necessary to enter into many details regarding yield tests by means of which the various lines
## TABLE 15.—Summary of Yield and Quality Characters of Country Gentleman Inbreds Used in Crosses

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>Frequency distribution, showing relation of each inbred to the others on basis of cross performance (Table 8)*</th>
<th>Recovery, compared with checksb</th>
<th>Summary of yield characters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unhusked ears</td>
<td>Husked ears</td>
<td>Cut kernels</td>
</tr>
<tr>
<td>1.</td>
<td>(+) (-) (0)</td>
<td>(+) (-) (0)</td>
<td>(+) (-) (0)</td>
</tr>
<tr>
<td>2.</td>
<td>7 1 4</td>
<td>7 0 5</td>
<td>5 0 7</td>
</tr>
<tr>
<td>3.</td>
<td>1 9 2</td>
<td>1 9 2</td>
<td>1 10 1</td>
</tr>
<tr>
<td>4.</td>
<td>4 3 5</td>
<td>4 4 4</td>
<td>3 3 6</td>
</tr>
<tr>
<td>5.</td>
<td>0 12 0</td>
<td>0 12 0</td>
<td>0 12 0</td>
</tr>
<tr>
<td>6.</td>
<td>11 0 0</td>
<td>6 0 6</td>
<td>4 1 7</td>
</tr>
<tr>
<td>7.</td>
<td>5 2 5</td>
<td>7 0 5</td>
<td>4 0 8</td>
</tr>
<tr>
<td>8.</td>
<td>2 7 3</td>
<td>1 3 2</td>
<td>1 2</td>
</tr>
<tr>
<td>9.</td>
<td>10 0 2</td>
<td>6 0 6</td>
<td>5 0 7</td>
</tr>
<tr>
<td>10.</td>
<td>5 2 5</td>
<td>4 0 8</td>
<td>4 1 7</td>
</tr>
<tr>
<td>11.</td>
<td>4 2 6</td>
<td>5 0 7</td>
<td>4 0 8</td>
</tr>
<tr>
<td>12.</td>
<td>1 4 6</td>
<td>4 2 5</td>
<td>6 0 5</td>
</tr>
<tr>
<td>13.</td>
<td>1 8 2</td>
<td>1 5 5</td>
<td>3 2 6</td>
</tr>
<tr>
<td>Top cross</td>
<td>3 4 5</td>
<td>2 8 2</td>
<td>2 4 6</td>
</tr>
</tbody>
</table>

### YIELD AND QUALITY CHARACTERS (Concluded)

<table>
<thead>
<tr>
<th>Inbred No.</th>
<th>Size of husked ears (Table 13)</th>
<th>Maturity, compared with checks (Table 12)</th>
<th>Amount smut on ears (Table 14)</th>
<th>Canning quality (Table 11)</th>
<th>Summary of quality characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Large</td>
<td>Same</td>
<td>Slight</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>2.</td>
<td>Small</td>
<td>Same</td>
<td>Considerable</td>
<td>Fair</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>3.</td>
<td>Normal</td>
<td>Slightly earlier</td>
<td>Slight</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>4.</td>
<td>Small</td>
<td>Slightly earlier</td>
<td>Slight</td>
<td>Distinctive</td>
<td>Unusual flavor, high quality</td>
</tr>
<tr>
<td>5.</td>
<td>Large</td>
<td>Same</td>
<td>Slight</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>6.</td>
<td>Larger</td>
<td>Earlier</td>
<td>Considerable</td>
<td>Good</td>
<td>Acceptable, but has smut</td>
</tr>
<tr>
<td>7.</td>
<td>Small</td>
<td>Earlier</td>
<td>Considerable</td>
<td>Fair</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>8.</td>
<td>Normal</td>
<td>Slightly later</td>
<td>Slight</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>9.</td>
<td>Normal</td>
<td>Slightly later</td>
<td>Very slight</td>
<td>Fair</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>10.</td>
<td>Normal</td>
<td>Same</td>
<td>Considerable</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>11.</td>
<td>Large</td>
<td>Same</td>
<td>Slight</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>12.</td>
<td>Small</td>
<td>Slightly earlier</td>
<td>Considerable</td>
<td>Fair</td>
<td>Not acceptable</td>
</tr>
<tr>
<td>13.</td>
<td>Large</td>
<td>Slightly earlier</td>
<td>Considerable</td>
<td>Fair</td>
<td>Not acceptable</td>
</tr>
</tbody>
</table>

*The frequencies were determined by the number of increases or decreases recorded for each inbred in Table 8. For an explanation of how these were calculated see footnote b of Table 8. The columns in Table 15 headed "+" show the statistically significant increases and the columns headed "-" show the statistically significant decreases. In the columns headed "0" the increases or decreases were due to chance and were not statistically significant.

*bIncreased or decreased percentages as compared with means of open-pollinated checks, complete results appearing in Table 10.

*Open-pollinated strain used as parent in top crosses.
were successively eliminated until only Inbreds 11, 13, 14, and 55 remained.

The methods of breeding and of testing the crosses were the same as those used with Country Gentleman. A summary of the trials is given in Table 16. Four Narrow Grain Evergreen crosses (14 × 13, 11 × 13, 11 × 14 and 11 × 55) were tested for periods varying from three to nine years. Altho these four crosses differ in type, the yields of cut kernels showed practically the same increases over the open-pollinated checks, varying only from 43.7 to 49.3 percent (Table 16). This consistency is surprising, because for only two of the crosses were the yields entering into the averages obtained during the same series of years.

Narrow Grain Evergreen Inbred 14 has been crossed commercially to a limited extent with Country Gentleman Inbreds 6 and 10 (Figs. 18 and 19, pages 349 and 350), producing an intermediate type having husked ears as large as the straight Narrow Grain Evergreen crosses, but yielding somewhat less cut corn (Table 16). The kernels of Crosses 14 × 10 and 14 × 6 are somewhat more slender and have slightly better quality in the can than straight Narrow Grain Evergreen crosses, but cannot, however, be classed as Country Gentleman according to Huelsen and Gillis.** Usually Crosses 14 × 10 and 14 × 6 segregate to some extent for ears having more or less of a zigzag kernel arrangement.

Choice between Narrow Grain Evergreen crosses is more likely to be based on ear type and size than on slight yield differences. Data on numbers of rows of kernels and length of fill on the cobs are therefore included (Table 17). This test was conducted in central Indiana thru the cooperation of a seedsman. As to numbers of rows of kernels, Cross 14 × 13 had few ears with more than 18 rows, but most of the ears of Cross 11 × 13 had from 18 to 20 rows, those of Cross 11 × 55 had from 18 to 22 rows. Cross 11 × 14 was intermediate, with most of the ears having 16 to 18 rows. The lack of uniformity of the open-pollinated strain is shown by the wide variation in numbers of rows ranging from 14 to 24.

In length of fill of kernels on the cob Cross 14 × 13 was somewhat shorter than the other three crosses, according to this test in Indiana (Table 17). This finding was not, however, in accordance with the data given in Table 16. Ordinarily the four crosses may be arranged 11 × 13, 11 × 55, 14 × 13, and 11 × 14 in order of decreasing length per ear, but this varies with soil and season. Ear length was definitely much less variable in the crosses than in the open-pollinated check.
Table 16.—Extent to Which Narrow Grain Evergreen Crosses Tested at Urbana Outyielded Open-Pollinated Strain of Same Variety
(Figures indicate percentage increase over open-pollinated checks*)

<table>
<thead>
<tr>
<th>Cross</th>
<th>Years tested</th>
<th>Number of tests averaged</th>
<th>Weights of unhusked ears</th>
<th>Weights of prime husked ears</th>
<th>Weights of prime cut kernels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total usable</td>
<td>Per ear</td>
<td>Total culls</td>
</tr>
<tr>
<td>14 X 13</td>
<td>1930, 1, 2, 4, 5, 6, 7, 8, 9</td>
<td>71</td>
<td>19.5</td>
<td>12.4</td>
<td>18.0</td>
</tr>
<tr>
<td>14 X 10</td>
<td>1937, 8</td>
<td>10</td>
<td>6.2</td>
<td>7.4</td>
<td>10.3</td>
</tr>
<tr>
<td>14 X 6</td>
<td>1931, 6, 7, 9</td>
<td>35</td>
<td>5.3</td>
<td>-2.6</td>
<td>-32.2</td>
</tr>
<tr>
<td>11 X 13</td>
<td>1935, 6, 7, 8</td>
<td>23</td>
<td>14.0</td>
<td>2.9</td>
<td>-20.8</td>
</tr>
<tr>
<td>11 X 14</td>
<td>1936, 7, 8</td>
<td>36</td>
<td>13.4</td>
<td>1.3</td>
<td>-23.9</td>
</tr>
<tr>
<td>11 X 55</td>
<td>1936, 7, 8</td>
<td>24</td>
<td>3.3</td>
<td>-5.8</td>
<td>-43.8</td>
</tr>
</tbody>
</table>

*The best open-pollinated Station strain was used as the check, the seed being ear-tested for germination and freedom from disease, but the crosses were not so tested.

bCommercial seedsman's stock for both years of 14 X 10 and in 1937 and 1939 for 14 X 6.
TABLE 17.—FREQUENCY DISTRIBUTIONS SHOWING PERCENTAGES OF TOTAL NUMBER OF EARS OF FOUR NARROW GRAIN EVERGREEN CROSSES AND AN OPEN-POLLINATED CHECK CLASSIFIED AS TO NUMBER OF ROWS AND LENGTH OF FILL ON THE EARS, 1939 TEST IN CENTRAL INDIANA

<table>
<thead>
<tr>
<th>Cross</th>
<th>Frequency distribution, percent of total number of ears having number of rows indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 rows</td>
</tr>
<tr>
<td>14 × 13</td>
<td>2.5</td>
</tr>
<tr>
<td>11 × 14</td>
<td>...</td>
</tr>
<tr>
<td>11 × 13</td>
<td>...</td>
</tr>
<tr>
<td>11 × 55</td>
<td>...</td>
</tr>
<tr>
<td>Open-pollinated check</td>
<td>...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency distribution, percent of total number of ears whose lengths② were—</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-5 inches</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>14 × 13</td>
</tr>
<tr>
<td>11 × 14</td>
</tr>
<tr>
<td>11 × 13</td>
</tr>
<tr>
<td>11 × 55</td>
</tr>
<tr>
<td>Open-pollinated check</td>
</tr>
</tbody>
</table>

①Not classified because of irregularity due to poor pollination.
②These are not the total ear lengths, but are the actual number of inches of kernels on the cobs.

DESCRIPTION OF INBRED LINES

The Illinois Country Gentleman and Illinois Narrow Grain Evergreen inbred lines that have been released by the Illinois Station for commercial production are described in the following sections. The descriptions apply to the inbred lines themselves, not to the crosses in which the inbreds are used as parents. In this respect these descriptions differ from those in the preceding discussion, in which the inbreds were evaluated according to their performance in crosses.

Illinois Country Gentleman Inbred 1

Relation to Other Inbreds. Remotely related to Inbred 15, and should therefore not be crossed with it.

Homozygosity. Uniform, inbred for seventeen generations.

Plant Characters. Height 5 to 6 feet, depending on soil and season; relatively few leaves and suckers; leaves wider than usual. Two-eared, vigorous, little or no lodging, good stalk (Fig. 2). Tassels large but very apt to blast in hot weather. Color of silk, sun-red.③

③A “sun” color is one which is brought out only when the silk is exposed to sunlight.
Ear Characters. Large, cylindrical, thick ears and long slender kernels, both of which characters are dominant in single crosses (Tables 11 and 13). Traces of rowing; tendency toward oval shape of cobs (Fig. 3). In some years kernel pericarps tend to split, owing to their tenderness. Canning quality of crosses is good.

Use in Crosses. In spite of poor tassels, Inbred 1 should ordinarily be used as the male parent in a cross, except in combination with Inbreds 6 and 10, which should not be used as seed parents. It so hap-

![Fig. 2.—Illinois Country Gentleman Inbred 1](image)

pens, however, that the best combinations of Inbred 1 are with Inbreds 6 and 10. For several years the Cross 1 × 6 gave excellent yields in commercial use, but in recent years Inbred 1 seems to have developed a tendency toward poor germination, and good field stands are consequently hard to get. This may be an unidentified genetic character, as there apparently was no unusual amount of rot or mold in the seed. Inbred 1 has therefore been withdrawn from commercial production, for the present at least.
Illinois Country Gentleman Inbreds 1 and 10, and Cross 1 × 10 (at right)

Inbred 1 was the seed parent and Inbred 10 the pollen parent.
Inbred 1 produces high-yielding crosses having a high recovery (Table 15). The ears of the crosses are large (Table 13), the quality good (Table 11), the maturity about the same as that of open-pollinated strains (Table 12), and the amount of smut is slight (Table 14).

Inbred 1 is the only one of these inbreds which gives a fairly good top cross (Table 5).

**Best Crosses.** 1 × 6 — Tall, vigorous, with medium-large, good Country-Gentleman-type ears. One ear out of sixteen is slightly rowed. Kernels long and slender, cobs slightly oval, canning quality extra fancy, yield good. Removed from commercial production pending improvements in Inbred 1.

1 × 10 — Tall and vigorous, resembling Cross' 1 × 6 in ear type (Fig. 3) but having longer kernels, no traces of rowing, and much better type of ear. An outstanding type, giving high yields. Canning quality fancy. Removed from commercial production pending improvement in Inbred 1.

**Illinois Country Gentleman Inbred 3**

**Relation to Other Inbreds.** None.

**Homozygosity.** Inbred for fifteen generations but still shows considerable variation in type. Some of these variants have been isolated and will breed true, but there is no evidence that they are superior to the parent line. In fact most of them seem to be inferior. When this inbred was grown in Idaho after twelve generations of inbreeding in Illinois, the variations were very pronounced. Whether this line is segregating, mutating, or simply fluctuating is not clear. However, the variations apparently do not detract from the value of the line.

**Plant Characters.** Vigorous, tall—on good soil in Illinois more than 6 feet tall. In Idaho, looks like open-pollinated Country Gentleman and yields as well or better. Tassels large, same amount of suckering as on open-pollinated strains. Tends to be leafy (Fig. 4). Medium to medium-long shanks; long, loose husks, sun-red silks.

**Ear Characters.** Large, slightly tapered ears and long, fairly slender kernels—characters which are dominant in crosses. Slight traces of rowing; cob slightly oval (Fig. 5).

**Use in Crosses.** Should be used as female parent. Crosses give fair yield and recovery (Table 5), husked ears the same size as open-pollinated strains (Table 13) but maturity slightly earlier (Table 12). Canning quality good. Smut damage generally slight (Table 14).

Because Inbred 3 has fair-sized kernels, the best cross combinations of it are with Inbreds 6 and 10.
Best Crosses. $3 \times 6$ — Tall, vigorous; good Country-Gentleman-type ears having long slender kernels (Fig. 5). Canning quality fancy. In commercial production to a limited extent, but not used in Illinois.

$3 \times 8$ — Tall, vigorous; tassels droopy; ears long, somewhat slender; kernels medium length, fairly slender; cobs slightly oval. Ear type not as good as some other crosses. Yield good; canning quality fancy. In commercial production until 1938 but was not popular owing to relatively large size of kernels.

$3 \times 10$ — Tall, vigorous; ears large and cylindrical; kernels long and slender; canning quality fancy. Exceptionally good ear type, resembling Cross $3 \times 6$. Not so resistant to drouth as Cross $3 \times 6$. Has been in commercial production.
FIG. 5.—ILLINOIS COUNTRY GENTLEMAN INBREDS 3 AND 6, AND CROSS 3 × 6 (at right)
Inbred 3 was the seed parent and Inbred 6 the pollen parent.
Illinois Country Gentleman Inbred 5

Relation to Other Inbreds. None.

Homozygosity. Most variable of all the eight Country Gentleman inbred lines released for production. Resembles Inbred 3 but shows much greater variation in character. Has been inbred for fifteen generations. Numerous widely diverse selections, many of which breed true, have been isolated, but thus far none of these (Table 4) seems to be consistently superior to the parent line. When grown in Idaho,

Fig. 6.—Illinois Country Gentleman Inbred 5

variability increases, as is true also of Inbred 3, and seed production there equals or exceeds that of open-pollinated Country Gentleman. The variations do not seem to detract from the value of the line. Crosses are uniform.

Plant Characters. Tall, vigorous plants, growing 6 feet or more high on good soil in Illinois. Stalks strong, usually two-eared; relatively few leaves and few suckers (Fig. 6). Tassels have shown a consistent tendency to blast in hot weather, but in the last few years
Fig. 7.—Illinois Country Gentleman Inbreds 5 and 10, and Cross 5 × 10 (at right)
Inbred 5 was the seed parent and Inbred 10 the pollen parent.
very rigid selection has improved the line considerably in this respect. This blasting seems to be a recessive character, as it does not appear in crosses. Tassels are good enough to propagate the line. Silks sun-red.

**Ear Characters.** Unusually large ears, free from rots and molds. Kernels finely wrinkled, of medium length and width (Fig. 7). Has a tendency to row; and pericarps occasionally split.

**Use in Crosses.** Should be used as female parent. Crosses generally have fairly high yields of unhusked ears (Table 15), a fair husking percentage, but only moderate recovery of cut corn. Husked ears large (Table 13); maturity about the same as that of open-pollinated strains (Table 12); canning quality good in general; smut slight (Table 14). Having large kernels, this inbred must be paired with lines having small slender kernels, such as Inbreds 6 and 10. Since the tassel is poor, the pollinator must have a vigorous tassel.

**Best Crosses.** 5 × 6 — Tall and vigorous; ears large, thick, cylindrical; kernels long, slender, finely wrinkled (when dry). Good yields; canning quality fancy. In commercial production to a limited extent.

5 × 10 — Tall and vigorous, producing a heavy yield of fodder; ears very similar to Cross 5 × 6. Usually six to twelve inches taller than Cross 5 × 6. Canning quality fancy. In yield tests Crosses 5 × 6 and 5 × 10 yielded the same, but there was some indication that Cross 5 × 10 resists drouth better. In commercial production (Fig. 7), and has proved to be second only to Cross 8 × 6 in popularity.

**Illinois Country Gentleman Inbred 6**

**Relation to Other Inbreds.** Previous to the sixth parental generation Inbreds 6 and 10 had a common parent.

**Homozygosity.** Inbred for seventeen generations; now fairly uniform. Minor variations in plant type occur, but these do not seem to be hereditary. Ear characters are well fixed.

**Plant Characters.** Tall, vigorous; few suckers; relatively few leaves (Fig. 8); mostly two-eared; silks sun-red. Height 6 feet or more on good soil in Illinois. Tassels good. Leaves in some seasons are yellowish green with small yellowish specks. Has considerable amount of smut both on ears and on plants.

**Ear Characters.** Ears large, symmetrical, completely zigzag; kernels long and very slender; cobs slightly oval (Figs. 5, 9, and 18). These characters are dominant. The single crosses have excellent ear type.

**Use in Crosses.** Most useful of the Country Gentleman inbreds.
Being characterized by a symmetrical ear with long, unusually slender kernels, and good quality, it has the ability to reproduce these characters in the cross. Therefore, any recommended cross in which Inbred 6 is used, has excellent ear type. The crosses have high yields, and a high recovery of prime husked ears and cut kernels (Table 15). Ears of the crosses are large (Table 13); maturity slightly earlier than open-pollinated strains (Table 12); canning quality high (Table 15). Tendency toward split pericarps in the crosses. Since it is susceptible to smut (Table 14), it must be paired with lines that are relatively re-

![Fig. 8.—Illinois Country Gentleman Inbred 6](image)

sistant to smut, such as Inbreds 1, 3, 5, and 8. Owing to the small size of the kernels and smut susceptibility, Inbred 6 should not be used as the seed parent in a cross.

**Best Crosses.** 1 × 6, 3 × 6, and 5 × 6 — Previously described under Inbreds 1, 3, and 5.

8 × 6 — Vigorous; slightly shorter than open-pollinated Country Gentleman; relatively few suckers. Ears slightly tapering, good Country Gentleman type (Fig. 9); kernels long and fairly slender.
Inbred 8 was the seed parent and Inbred 6 the pollen parent.
Canning quality consistently fancy. Tassels droopy and thus well protected from the sun; has never been known to fail to produce plenty of pollen. Droopy tassels cause irregularities in height of plant, which give the impression that this cross lacks uniformity in comparison with other crosses. Actually very uniform in all respects except height. Only segregation noted is with reference to tassel ears, a very small percentage of which appear each year.

This cross \((8 \times 6)\), now in production on a large scale, is more widely used than any of the other Country Gentleman crosses discussed here. It seems to have a relatively wide adaptation in the Middle West. Its production is somewhat deceptive: The yields of unhusked ears may not exceed those of open-pollinated Country Gentleman (Table 1), but the percentage of recovery is very high (Table 1) and the yields of cut kernels or of cases of corn per acre are higher than those of open-pollinated strains. In tests by Neal\(^{12}\) in Wisconsin, Cross \(8 \times 6\) produced as much as 41.9 cases per ton, compared with 24.1 cases of open-pollinated Country Gentleman, total production being, respectively, 125.3 and 89.5 cases per acre. Yields of unhusked corn were, however, 3.71 tons per acre of open-pollinated Country Gentleman and only 3.30 tons of Cross \(8 \times 6\). High recovery such as this is very desirable from the canners’ viewpoint, as the value of the raw product per gross ton is much higher.

**Illinois Country Gentleman Inbred 8**

*Relation to Other Inbreds.* Closely related to Inbred 9.

*Homozygosity.* Inbred for seventeen generations; most uniform of all the inbreds described in this publication. A number of true-breeding plant variants have been isolated, but few of these have given any better results than the original line (Table 4). Ear characters show very little variation.

*Plant Characters.* Highly characteristic features quite different from any other sweet corn now in production (Fig. 10). Vigorous; considerable foliage; suckers freely. Leaves dark green; silks green. Growth is normal but somewhat bushy up to the time of tasseling. Not very susceptible to smut; some smut usually appears on the tassels but very little on the ears. Tassel unusually large and drooping, producing plentiful amounts of pollen and not straightening until pollen is actually shedding. The tassel is thus completely protected from the sun, so that even in the severest heat and drouth there is no injury to the anthers. This very desirable character is dominant in all crosses in which Inbred 8 is used as a parent.
The drooping of the tassels seems to be due to abnormal growth of the stalk evident in the forming of short internodes above the shoot but normal ones below. Apparently the length of the internodes above the shoots depends somewhat upon the stage of development reached when the tassels straighten up, some straightening later than others. This has the effect of varying the height and preventing the uniform appearance at maturity which is generally characteristic of inbred lines.

Maturity is slightly later than that of any other of the inbreds except Inbred 9. It is desirable, therefore, to plant Inbred 8 five to seven days before planting the pollen parent, tho ordinarily in Illinois it does not develop too late if planted at the same time as the pollen parent. In Idaho a fourteen-day spread in planting is necessary.

Inbred 8 shows a slight amount of segregation for tassel ears. When it is grown in Idaho, rudimentary tassels appear at the end of 75 percent of the cobs, but selections free from this character have been made. In the Middle West and in the East cob tassels do not appear in any of the strains of Inbred 8.
Ear Characters. Very long and slender but heavy in weight (Fig. 9). Kernels large in diameter but short. These ear characters limit the use of Inbred 8 in crosses, as the other parent must have long slender kernels and a rather thick ear. Seed quality, however, is excellent.

Use in Crosses. Should be used as the seed parent in crosses, but owing to the droopy tassel the operation of detasseling is somewhat more difficult than in inbreds not having this character. Superior in crosses to Inbred 9 (to which it is closely related), despite the fact that in general vigor and appearance Inbred 9 is the better-looking line. Crosses involving Inbred 8 generally produce good yields of all three yield components: unhusked ears, prime husked ears, and cut kernels (Tables 10 and 15). In compatible crosses the husked ears are the same size as those of open-pollinated strains (Table 13), and maturity also is the same (Table 12). Canning quality is good. Only a slight amount of smut appears in the crosses, as Inbred 8 is relatively resistant to smut (Table 14).

Best Crosses. 3 × 8 — Described under Inbred 3.
8 × 6 — Described under Inbred 6.
8 × 10 — Very similar to Cross 8 × 6 but taller and more vigorous. Yields good (Table 5); ears equal to those of Cross 8 × 6. This cross has not entered commercial production, because it is not quite so productive as Cross 8 × 6, as shown by extensive tests in 1939 of crosses made with several strains of Inbreds 8 and 10.

Illinois Country Gentleman Inbred 9

Inbred 9 is closely related to Inbred 8, has exactly the same physical characters, but when the two are placed side by side Inbred 9 is superior in all respects. However, Inbred 8 produces uniformly superior crosses, and for that reason Inbred 9 has been withdrawn from commercial production.

Illinois Country Gentleman Inbred 10

Relation to Other Inbreds. Closely related to Inbred 6.

Homozygosity. Inbred for seventeen generations; now fairly uniform tho slightly different plant types which breed true can still be isolated. A green-silk, yellow-anther type was isolated in 1937. Ear characters, however, are well fixed.

Plant Characters. Resembles Inbred 6 rather closely except that it is more vigorous and slightly taller (Fig. 11) and does not have speckled leaves. Less susceptible to smut than Inbred 6.
Ear Characters. Very similar to Inbred 6 except that kernels are slightly larger and ears usually larger (Figs. 3, 7, 12, and 19).

Use in Crosses. Altho Inbreds 6 and 10 are closely related and quite similar in appearance, they are not interchangeable in crosses. In crosses Inbred 10 is comparable to Inbred 6 in giving high yield and high recovery (Table 15). The ears in compatible crosses are large (Table 13), and maturity is slightly earlier (Table 12) than in open-pollinated strains. Canning quality is equal to that of Inbred 6. In spite of Inbred 10 being less susceptible to smut than Inbred 6 the crosses on the whole have as much smut as Inbred 6 (Table 14). In the best combinations, however, Inbred 10 gives plants having larger ears and less smut than those given by Inbred 6. Owing to its small kernels Inbred 10 should be used as the pollen parent.

Best Crosses. 3 × 10 — Described under Inbred 3.
5 × 10 — Described under Inbred 5.
8 × 10 — Described under Inbred 8.
Fig. 12.—Illinois Country Gentleman Inbreds 10 and 15, and Cross 10 × 15 (at right)
Inbred 10 was the seed parent and Inbred 15 the pollen parent.
Illinois Country Gentleman Inbred 15

Relation to Other Inbreds. Remotely related to Inbred 1.

Homozygosity. Inbred for fifteen generations; fairly uniform for plant characters; little variation in ear characters. Several generations of growth in Idaho have produced a number of quite different segregates which may eventually prove to be superior.

Plant Characters. Tall (5 to 6 feet); leaves yellowish, mottled, subject to dying-back more or less, even in favorable growing seasons (Fig. 13). Dying-back of the leaves does not seem to be associated with any disease. Maturity, among the earliest of the inbreds. Subject to tassel-blasting in hot dry weather, but has been improved in this respect in recent years. Tassels and stalk susceptible to smut.

Ear Characters. Ears medium-sized, somewhat slender; kernels relatively short and broad, dark in color, finely wrinkled, and frequently have the silks adhering to them (Fig. 12). Pericarps split in some seasons. Slight traces of rowing, probably due to the fact
that some of the kernels are almost always aborted. Ears relatively free from rots and molds.

*Use in Crosses.* Owing to its low seed production Inbred 15 should be used as the pollen parent in crosses. Crosses have low yields of unhusked ears (Tables 8 and 15) but very high recovery (Table 10), thus producing corn which has a high tonnage value and heavy production of cases per acre. Husked ears of crosses are large (Table 13). Maturity about the same as that of open-pollinated strains (Table 12).

Tho Inbred 15 has a number of undesirable characters, many of the crosses in which it has been used have given excellent yields of corn having unusually good canning quality (Tables 5 and 15). The canned kernels are white (Table 11).

Inbred 15 has been in limited production only. None of the crosses are available commercially.

*Best Crosses.* 8 × 15 — Long, somewhat slender ears with long slender kernels. Some ears have slight traces of kernel-rowing. Yields good; canning quality good.

10 × 15 and 6 × 15 — Medium-sized, somewhat thick ears with very long slender kernels. Canning quality exceptionally good and yields also good.

**Illinois Narrow Grain Evergreen Inbred 11**

*Relation to Other Inbreds.* None.

*Homozygosity.* Inbred for seventeen generations but has tended to be somewhat unstable, segregating several times, the last in P12. This lack of stability in the inbred, however, seems not to affect the types or yields of the crosses.

*Plant Characters.* Very tall, averaging 6 to 7 feet in Illinois. Relatively leafy, few suckers, tassels erect and surrounded by erect leaves. Well-eared, shanks medium length, flag leaves few, husk coverage only average. Does not have much smut.

*Ear Characters.* Good seed-producer; rowing irregular, 18 to 22 rows; ears long; kernels somewhat slender, medium in length and width, and having some split pericarps (Fig. 14).

*Use in Crosses.* Has given some trouble with tassel-blasting in hot weather, but the selections released to seedsmen in 1939 seem to have much better tassels. Should be used as the seed parent until tassels have been proven by experience not to blast in hot weather.

*Best Crosses.* 11 × 13 (13 × 11) — Unusually large, somewhat tapering ears 8 to 9 inches long; eighteen to twenty rows, practically
Inbred 11 was the seed parent and Inbred 13 was the pollen parent.

no ears having fewer than eighteen rows. Kernels long and slender; canning quality excellent. Plants unusually tall, varying from 8 to 9 feet, which averages about 1 foot taller than open-pollinated Narrow Grain Evergreen. Suckers few; practically no lodging. An unusually desirable type because of its large ears and slender kernels.

11 × 14 (14 × 11) — See under Inbred 14.
11 × 55 (55 × 11) — Very large, symmetrical, straight-rowed ears 7 to 9 inches long; eighteen to twenty-two rows, practically no ears
having fewer than eighteen rows. Kernels long and slender; canning quality excellent. Plants average 8 feet tall; few suckers; good husk coverage; shanks occasionally somewhat long; practically no lodging. Like Cross 11 × 13 this is an unusually desirable type because of high-quality ears and long slender kernels (Fig. 20).

Illinois Narrow Grain Evergreen Inbred 13

Relation to Other Inbreds. None.

Homozygosity. Inbred for seventeen generations; has shown but little variation in later generations. Repeated selections out of the parent line do not deviate very much from the original.

Fig. 15.—Illinois Narrow Grain Evergreen Inbred 13

Plant Characters. Tall, vigorous, attaining a height of 6 feet or more in Illinois under favorable conditions; leaves numerous, dark green, relatively narrow; suckers rather freely; large straggly tassels not subject to blasting in hot weather (Fig. 15). Sun-red silks and long husks. In maturity this line is slightly later than Inbred 14.
Fig. 16.—Illinois Narrow Grain Evergreen Inbreds 14 and 13, and Cross 14 × 13 (at right)

Inbred 14 was the seed parent and Inbred 13 was the pollen parent.
Ear Characters. Large tapering ears, large butts, fourteen to sixteen rows, rowing irregular, kernels long, medium width (Fig. 16).

Use in Crosses. Owing to its excellent tassel characters and slightly later maturity than is exhibited by many inbreds, Inbred 13 should be used as a male in crosses.

Best Crosses. So far the best combinations seem to be Cross 14 × 13 (Fig. 16) and Cross 11 × 13 (Fig. 14). Crosses with Country Gentleman Inbreds 6 and 10 give high yields but the ears tend to be long and slender, with very indistinct rowing.

Illinois Narrow Grain Evergreen Inbred 14

Relation to Other Inbreds. None.

Homozygosity. Inbred for seventeen generations; has shown but little variation in the last eight years altho repeated selections have been made. "Prepotent" or "dominant" in the sense that it is practically always possible to recognize easily any cross in which it is used.

Plant Characters. Very tall, averaging 7 feet in Illinois; leaves few and relatively narrow; suckers few; tassels relatively small, with few branches (Fig. 17). Well-eared; shanks medium to medium-long; husks long; flag leaves few; silks sun-red. Tassel seeds on suckers, but seldom on main stalks. Susceptible to smut in the tassels and to some extent on the stalks, but relatively little on the ears.

Ear Characters. Ears relatively large, with twelve to sixteen rows (Figs. 16, 18, and 19); unusually bright and clean, with translucent kernels. Kernels medium in length and width, and finely wrinkled.

Use in Crosses. As Inbred 14 is a heavy seed-producer, it should be used as the seed parent in crosses except possibly with Inbred 11. Crosses well with many inbred lines. When combined with Country Gentleman Inbreds 6 or 10, a good type of ear is assured.

Best Crosses. 14 × 6 — Large, slightly tapering ears, sixteen to eighteen rows slightly irregular and on occasional ears quite irregular (Fig. 18). Kernels medium in width and length. Canning quality excellent, yield high. Distinctly a Narrow Grain Evergreen type and cannot be substituted for Country Gentleman. Plants are 8 feet tall, slightly larger than open-pollinated Narrow Grain Evergreen.

14 × 10 — Large, slightly tapering ears; fourteen to eighteen rows, resembling Cross 14 × 6 very closely both in ear and kernel type (Fig. 19) and in plant type. Under some conditions Cross 14 × 10 gives better yields and larger ears than Cross 14 × 6. Canning quality good.
14 × 13 — Extremely large cylindrical ears; fourteen to twenty-two rows, practically straight (Fig. 16). Kernels long and medium-wide. Height about 8 feet, slightly taller than open-pollinated Narrow Grain Evergreen. Yields higher under most conditions than Cross 14 × 6 or Cross 14 × 10, but the canning quality is not quite so good. Superior in quality, however, to open-pollinated Narrow Grain Evergreen.

14 × 11 (11 × 14) — Best direction in which to make this cross not definitely known, as it does not go into commercial production until 1940. Ears large and symmetrical; sixteen to twenty straight rows (Fig. 20). Kernels long and slender. Height 8 to 9 feet; suckers few; husks good; very little lodging. Quality of canned corn excellent, superior to open-pollinated Narrow Grain Evergreen.

**Illinois Narrow Grain Evergreen Inbred 55**

*Relation to Other Inbreds.* None.

*Homozygosity.* Inbred for fifteen generations; has not changed in appearance for many years.
Inbred 14 was the seed parent and Inbred 6 the pollen parent.
Inbred 14 was the seed parent and Inbred 10 the pollen parent.
Inbred 11 was the seed parent in both crosses, and Inbreds 55 and 14 were the pollen parents.
Plant Characters. Very tall, averaging 7 to 8 feet; unusually vigorous. Stalks very sturdy; suckers few; tassels large and well protected, free from blasting. Silks red. Shanks tend to be long. Lodging very infrequent. Very little smut.

Ear Characters. Good seed-producer, with 1 to 2 ears per stalk. The dry ears are large, unusually heavy, dark and dull looking. Fourteen to eighteen rows, but rowing irregular (Fig. 20). Kernels medium in length and width, packed very tightly on cobs; shelling not easy.

Use in Crosses. May be used either as pollen or as seed parent. The best combination seems to be with Inbred 11, with which it may be used as either the seed parent or the pollen parent.

Best Crosses. 11 × 55 (55 × 11) — Described under Inbred 11.

SUMMARY AND CONCLUSIONS

From sweet-corn breeding begun in 1922 at the Illinois Agricultural Experiment Station a number of inbred lines and single crosses between the inbred lines have been developed and released for commercial production, and in addition light has been thrown on some of the problems involved in inbreeding, selection within inbred lines, and hybridization. The work reported in this bulletin has been done with the Country Gentleman and Narrow Grain Evergreen varieties, but yellow varieties have also been included in the program since 1930. Twelve inbreds (eight of Country Gentleman and four of Narrow Grain Evergreen) have been released at various times for commercial propagation. Three of the Country Gentleman inbreds were withdrawn for different reasons after being released.

The principal facts pertaining to these inbreds and their crosses, and some of the more significant conclusions to be drawn from the breeding work, are the following:

Yields.—From the standpoint of yields of sweet corn, the superiority of good single crosses over good open-pollinated strains of the same variety was chiefly a matter of (1) a decreased variation of yield from year to year by the crosses, and (2) a significantly greater recovery of prime cut kernels per ton of unhusked ears from the crosses.

During the six years 1931, 1933-1937, including three years of severe drouth, the coefficient of variability in yield of the well-adapted Cross 8 × 6 was 29.5 percent on the basis of tons of prime cut kernels per acre, while that of the open-pollinated check was 45.1 percent. During the same years the recovery of cut kernels per ton of unhusked ears was 22.6 percent higher from the cross than from the
open-pollinated check. Such differences are typical, and because of their existence the yield of sorted unhusked ears is not so reliable as the yield of prime cut kernels as a basis for estimating the value of a single cross. During the six years the cross produced 41.8 percent more tons of prime cut kernels per acre than the check, but only 33.9 percent more prime husked ears, and 18.6 percent more sorted unhusked ears.

Adaptability.—Even after seventeen generations of inbreeding in Illinois, when a high degree of homozygosity had presumably been attained, the removal of the inbreds to the highly favorable seed-producing regions of Idaho and Connecticut resulted ultimately in segregation, mutation, and general deterioration. In three-year tests the yields of corn grown in Illinois from crosses of Illinois inbreds maintained and crossed in Idaho ranged from 1.6 to 36.4 percent below the yields of corn grown from crosses of Illinois inbreds maintained and crossed in Illinois. Similar tests with Purdue 39 and Purdue 51 inbreds maintained and crossed for three successive years in Idaho showed that the cross, Golden Cross Bantam, deteriorated very rapidly and progressively in yield. On the basis of these and similar trials the more progressive seedmen are now maintaining their inbreds in the Middle West and merely making the crosses in Idaho. Whether or not this method will prove satisfactory is still uncertain.

As to the adaptability of crosses to different regions, the data available are too limited to give a conclusive answer, but it is believed that a successful single cross must have a more than local range. Crosses restricted in range may also prove to be equally restricted in adaptability to variations in local weather conditions.

Effect of Continued Selection Within Inbreds.—Not much progress could be made toward improving crosses by means of selections within the inbred parents on the basis of physical characters.

Selection on this basis proved to be more promising, however, in unstable than in stable lines. When selections of any kind are made, the only known basis for determining their value is to cross and to check the cross for the desired characters.

Selective Use in Crosses.—On the basis of numerous yield tests the various inbreds were classified as to their best use in crosses—that is, whether as pollen parent or as seed parent. When their selectivity in this respect was determined, the crosses could then be classified as compatible, incompatible, and antagonistic.

Of these three kinds of crosses the compatible crosses were usually superior to the incompatible and antagonistic crosses. Some of the
differences were due to physiological causes, such as size of seed or susceptibility to seed-borne diseases, but there was a residue apparently due to unknown genetic causes.

*Bases for Evaluation of Inbreds.*—The inbred lines were evaluated first on the bases of appearance, quality, and yields; then when a fair degree of uniformity in these respects had been attained, they were further evaluated by measuring their performance in crosses. By averaging the yields and other measures of performance of a series of reciprocal crosses, the selectivity of the parents and their desirable characters and defects could be determined—an important point since the heredity of the quantitative characters is unknown.

Quality as well as yield seemed to be definitely associated with inbred lines, inasmuch as given quality characters ran thru a series of crosses in which the same parent had been used, indicating that hereditary characters were involved. Altho none of the twelve released inbreds were consistently poor in quality, a fact which was to be expected inasmuch as they had been selected as the most promising out of more than one hundred lines, some differences did, nevertheless, exist. Inbred 4, for instance, was outstanding in the quality of its crosses, particularly in their flavor.

In maturity most of the crosses were slightly earlier than the open-pollinated checks. Some of the inbreds, however, produced later-maturing crosses than others. Size of seed had an effect on maturity. The small-seeded Inbred 6, when used as seed parent, produced crosses maturing definitely later than the crosses produced when it was used as pollen parent.

The inbreds showed considerable variation in weight per husked ear. Some lines had consistently lighter-weight ears than others, indicating that this quantitative character is probably hereditary.

A similar variation in incidence of smut on the ears was observed. The crosses of some inbred lines had, on the average, very little smut on the ears; those of other lines had much more.

*Best Crosses.*—Because of superior canning quality, wide adaptability, high yields of prime cut kernels, and resistance to drouth, smut, and tassel-blasting, the two Country Gentleman Crosses 8 × 6 and 5 × 10 have proved to be the most popular of all the crosses of the inbreds released by this Station. Of these two, Cross 8 × 6 has been much more popular than Cross 5 × 10. Numerous tests by other stations and by growers and canners have demonstrated that these two crosses may be grown successfully wherever open-pollinated Country Gentleman strains succeed.
Of the Narrow Grain Evergreen crosses, Cross 14 × 13, available since 1937, has been the most popular, tho it has been much less widely grown in Illinois than the Country Gentleman crosses. Probably one or more of the new group of Narrow Grain Evergreen crosses released for 1940, crosses between Inbreds 11 and 13, 11 and 14, and 11 and 55, will find a wide use. Because of more economical production when several crosses can be made using one inbred as the male parent for all, these crosses will probably be marketed as Crosses 13 × 11, 14 × 11, and 55 × 11. More widely adaptable than the Country Gentleman crosses, these crosses can be grown successfully wherever open-pollinated Narrow Grain Evergreen strains succeed.

LITERATURE CITED


Policy Governing Seed Distribution

Seed of the new sweet-corn inbreds and crosses described in this bulletin is not available at the Illinois Agricultural Experiment Station either for sale or for free distribution. Inbreds are available only to commercial seedsmen who have the necessary equipment and experience for maintaining them and for properly producing the crosses, and who sign an agreement with the Board of Trustees of the University of Illinois to produce the crosses under Station supervision. Seed of the crosses is available from these commercial seedsmen. Write to the Illinois Station for further information.